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DIAGNOSIS OF BOVINE PREGNANCY BY MEASURING VAGINAL RESPONSE TO OXYTOCIN [1]

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TWO methods frequently used for the detection of pregnancy in the cow are (a) observations of return or non-return to estrus and (b) palpation of the cow's reproductive tract and associated structures. The first method is reliable, especially if 2 to 3 months elapse between copulation and the final diagnosis. Successful determinations of pregnancy by the end of the first month have been claimed by some workers using the palpation technique, but a greater accuracy of diagnosis by this method has been achieved by others after two or more months have passed. A reliable method for the determination of pregnancy, especially during the early stages, should be of economic value to producers wishing to avoid wintering or feeding nonpregnant cows, producers planning to dispose of animals thought to be nonpregnant, and buyers and sellers of bred stock or of feeder heifers. This present study was initiated in an attempt to develop, if possible, a practical method for the determination of early pregnancy in the cow.

Materials and Methods

A group of 19 cows (16 Holsteins, 2 Jersey, and 1 Guernsey) belonging to the Dairy Cattle Research Branch,[3] A.R.S., U.S.D.A. were used primarily for a series of preliminary trials. Tests using these cows were made at various times of the day, mainly during the period between the morning and afternoon milkings. A total of 302 cows (252 Holstein, 15 Guernsey, 13 Jersey, 11 Ayrshire, and 11 Aberdeen-Angus) were used to test the efficacy of the developed method.[4, 5] About one-half of the dairy animals were tested 10 to 45 minutes prior to morning or afternoon milking and the others no sooner than 15 minutes after milking. Eight of the 11 beef cows were nursing calves, but were separated from their offspring at least 30 minutes prior to testing.

The method as finally developed for conducting the vaginal response

[1] Scientific Article No. A688, Contribution No. 2097 of the Maryland Agricultural Experiment Station, University of Maryland (Department of Animal Husbandry). The data presented were taken from one section of a thesis submitted by the senior author to the Graduate School of the University of Maryland in partial fulfillment of the requirements for the degree of Master of Science; Tavenner (1958).

[2] Professor of Animal Husbandry.

[3] The authors wish to express their appreciation to J. F. Sykes and J. W. Thomas for their cooperation.

[4] The dairy animals were made available through the courtesy of R. F. Davis, Head, Dairy Department, University of Maryland.

[5] The beef animals were furnished through the courtesy of J. E. Foster, Head, Department of Animal Husbandry, University of Maryland.

to oxytocin test for pregnancy may be divided into two major parts. Results of various trials upon which the test is based are presented in the "Results" section.

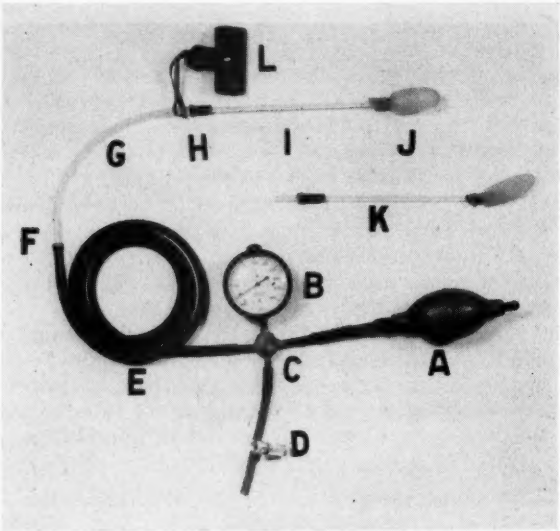

Figure 1. Apparatus used for measuring changes of the vaginal pressure

A Double acting squeeze bulb hand pump (60 ml. capacity)
B Manometer (300 mm./Hg capacity)
C "4 way" junction
D Air release hose and pinch type stop cock
E Rubber tubing (3' x 3/16")
F Jointer (3" section of plastic, artificial insemination catheter)
G Flexible plastic tubing (12" x 1/4")
H Jointer (2" section of 3/16" rubber tubing)
I Catheter (9" section of artificial insemination catheter)
J Balloon (thumb finger portion of surgical rubber glove)
K Vaginal balloon-catheter section
L Spring clamp

Step 1—Administration of oxytocin. The cow was secured in a squeeze chute or stanchion (U. of Md. dairy cows), haltered, and the head securely restrained in a position which would permit access to the ventral portion of the neck. Thirty units of oxytocin [6] were injected intrajugularly by means of a sterile, 18-gauge, 1.5-inch hypodermic needle attached to a

[6] The oxytocin preparation, "Purified Oxytocin Principal", was a sterile, aqueous solution containing the equivalent of 20 U.S.P. units per cc. It was furnished through the courtesy of the Veterinary Laboratories of the Armour and Company.

5-cc. hypodermic syringe. After the oxytocin was injected, the head was freed.

Step 2—Measuring vaginal contractions. The developed apparatus, shown in figure 1, was manipulated in the following manner: The catheter with the rubber balloon attached was inserted into the vagina until the catheter rested against the cervix, which was located easily by means of gentle probing. Then, the plastic tube (figure 1, G) was curved and fastened to the hair near the median plane just anterior to the tail by means of a spring clamp (figure 1, L). The stopcock (figure 1, D) was closed and 60 cc. of air pumped into the system by use of the hand pump (figure 1, A).

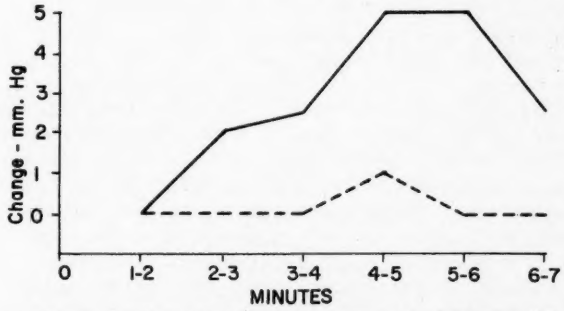

Figure 2. "Typical" changes in intra-vaginal pressure following injection of oxytocin. Pregnant cow (solid line). Nonpregnant cow (dotted line).

All pressures were measured and recorded in terms of mm. of mercury. Initial pressure readings were taken within one minute after the injection of the oxytocin. Manometer readings were observed continuously and changes in pressure were recorded within successive intervals of one minute from the time of injection. In conducting the test, as developed, recording of pressures was maintained for 7 minutes. After readings were made, the air was released from the system, the apparatus was removed from the cow, and all necessary parts were disinfected.

Diagnosis of pregnancy by the method herein described was based on the amount and time of change of pressure. The pattern for pregnant cows was, in general, an increase, relative to the initial reading of approximately 5 to 10 mm. Hg about 3 to 4 minutes post-injection. The increased pressure would be maintained for approximately 2 minutes. At 5 to 6 minutes, the pressure would start to return to the initial reading. Little if any change from initial pressure was usually exhibited by nonpregnant cows not in estrus (see figure 2). In some instances, however, nonpregnant cows caused as much change in pressure as did pregnant animals but the pattern

of the increase was usually that of rapid fluctuations, inconsistant in time or amount. For purposes of this study, each cow was designated as either "pregnant" or "nonpregnant", none being placed in a "doubtful" category.

Efficacy of the test, as described, was based on three methods of estimating or determining "actual" pregnancy. Herd records were examined for the dates of estrus, breeding, and/or freshening. A qualified veterinarian used the palpation technique for any questionable cases. Reproductive tracts of three slaughtered cows were examined. Cows were listed as "known pregnant" or "known nonpregnant" on the above bases. The percent of accuracy of the developed method was determined by comparing the number of cows diagnosed as "pregnant" or "nonpregnant" and the results of the above three ways of establishing the presence of "actual" pregnancy.

Results [7]

One of the first studies was related to finding a satisfactory material for the vaginal balloon (figure 1, J). The specifications demanded that the balloon be expandable, pliable, and durable to the conditions of disinfection (a chlorine solution) and of the vagina. Rubber bags used for collecting bull semen were of poor elasticity. Common condoms tended to fold and prevent a free flow of air. Toy balloons lost their elasticity. Plastic bags developed weakened areas and lost their continuity of shape. Thumb or finger portions of latex surgical rubber gloves, as suggested by Hays and VanDemark (1953), proved to be satisfactory. The thumb portion was most satisfactory as it expanded more uniformly when the standard 60-cc. volume of air was introduced into the system.

The next study concerned the relative efficiency of using a constant initial pressure (air volume varying) or a variable initial pressure (air volume constant) in the vaginal ballon—manometer system. Constant initial pressure was tried and discarded because: (a) considerable variation in air volume was needed from cow to cow, (b) variations in air volume were found, by means of rectal palpation, to affect the size of the balloon, and (c) variations in size of the balloon affected its ability to transmit slight changes in pressure. Laboratory tests indicated that the introduction of approximately 60 cc. of air into the system permitted satisfactory registration of changes of internal pressure when varying amounts of pressure were applied to the exterior of the balloon. One complete evacuation of the hand pump (squeeze bulb, figure 1, A) yielded essentially 60 cc. of air quite consistently.

Three pregnant and nine nonpregnant cows were each injected with 30 units of oxytocin. Vaginal contractions which increased manometric read-

[7] One portion of this section will be concerned with studies related to the development of the previously described technique. These studies will be given on a subject matter rather than a chronological basis. The second portion of this section will include trials for the testing of the efficacy of the developed technique.

TABLE 1. EFFECT OF DIFFERENT DOSAGE LEVELS OF OXYTOCIN ON MANOMETRIC READINGS. (PREGNANT COWS)

No. of cows	Units	Average initial reading	Change from initial reading at intervals (in minutes) after injection								
			1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10
2	5	37.5	—1.0	—1.0	—1.0	0.5	—1.0	—1.0	—1.0	—1.0	—1.0
3	10	36.7	0.0	1.7	0.0	1.7	2.5	3.8	8.8	5.0	1.7
4	20	37.5	3.0	7.1	7.5	4.3	5.0	6.7	6.3	2.3	4.2
5	30	40.0	0.0	5.0	7.5	6.9	6.3	7.1	4.4	5.0	1.0
4	40	40.0	1.3	6.0	7.5	7.0	6.0	5.8	5.0	1.3	0.0
4	50	36.3	3.0	3.8	2.5	4.2	4.2	—0.5	—0.5	0.8	0.6
3	60	41.7	0.0	2.5	4.0	5.0	1.0	0.8	—3.0	—3.0	—1.3

ings by 5 to 10 mm. Hg over initial pressures were produced by the pregnant cows. No increase in pressure was produced by the nonpregnant cows which were not in estrus. Pregnant cows were then injected with different amounts of oxytocin in order to find a satisfactory dosage. Manometric readings were recorded for a period of 10 minutes post injection in all preliminary trials. Differences between initial and subsequent readings were calculated and averaged. In instances where changes in pressure were noted within any one-minute interval, the pressures were recorded and entered into the averages. The results are shown in table 1. Two cows received all seven dosage levels over a period of seven days. Dosage levels of 20, 30, and 40 units appeared to give the most consistent response in both time and amount of increase of pressure.

Combinations of three volumes of introduced air and two dosage levels of oxytocin were used in an effort to determine the best combination of volume of air and dosage. The results presented in table 2 indicate that 60 cc. of air and 30 units of oxytocin gave the best results.

The reactions of cows in various phases of the estrous cycle were tested in two trials. The first involved the giving of 20, 30, and 40 units of oxytocin to each of three cows in the diestrous phase of their cycle. In each instance there was either no change or a decrease from initial manometric pressure ranging from —2 to —10 mm. Hg. In the second trial,

TABLE 2. CHANGES IN VAGINAL PRESSURES IN RELATION TO DIFFERENT VOLUMES OF AIR AND DOSAGE LEVELS OF OXYTOCIN. (PREGNANT COWS)

No. unit oxytocin	Volume of air, cc.	Changes from initial pressure (mm. Hg) during intervals (minutes) post-injection as indicated			
		3–4	4–5	5–6	6–7
20	60	0	4	6	4
20	120	0	6	4	4
20	180	–	4	4	3
30	60	1	6	9	5
30	120	0	4	6	3
30	180	0	3	4	1

four nonpregnant cows were each assigned to one dosage level (10, 20, 30 or 40 units of oxytocin) and injected during different phases of their estrous cycles. In each case, changes in vaginal pressures were small and erratic during estimated metestrum, diestrum, and proestrum (1, 8–11, and 18–20 days post estrus, respectively). The changes in pressure were mainly zero to —2 to —3 mm. Hg for all cows especially during diestrum and proestrum and was the same during metestrum for the cow receiving 10 units. Animals receiving 30 or 40 units during metestrum exhibited irregularly spaced increased pressures of 2 to 3 mm. Hg which lasted for one minute or less. During estrus, increases over initial pressures of about 4 mm. Hg were found from 3 to 10 minutes after injection. These changes were similar to the changes exhibited by pregnant cows.

TABLE 3. RESULTS OF "VAGINAL RESPONSE TO OXYTOCIN TEST" BY BREED

Breed	No. of cows	Known pregnant cows		Known nonpregnant cows		Percent of accuracy
		No. giving pregnant reaction	No. giving non-pregnant reaction	No. giving pregnant reaction	No. giving non-pregnant reaction	
Aberdeen-Angus	11	11	0	0	0	100
Ayrshire	11	7	0	2	2	82
Guernsey	16	9	1	1	5	88
Holstein	268	142	18	13	95	88
Jersey	15	8	0	3	4	80
Total	321	177	19	19[a]	106	

[a] Six of 19 cows were in oestrum on the date they were tested and three other cows were diagnosed by a veterinarian to have cystic ovaries. Theses three also had histories of constant oestrum.

Effects of different levels of oxytocin on the continuation of pregnancy were studied both directly and indirectly. One cow was injected with 40 units of oxytocin 5 days before calving and again with 20 units one day pre-partum. No changes from initial pressures were found either time. A second cow was injected with 30 units, 4 days before calving and with 60 units of oxytocin the day before calving. No changes in pressure were found for 10 minutes following the 30 unit dose but fluctuating changes from zero to 5 mm. Hg were found for 9 minutes after injection when the 60 units were given. Both of these cows and all of the pregnant cows used in the above studies calved normally and at the expected time.

The accuracy of the developed technique was estimated from a series of tests involving 321 cows. Each cow was tested in the order as stalled, or caught in the case of the beef cows, without regard to her reproductive state. This procedure varied a little from that which might be found under

farm conditions, as in the latter case cows in estrus or diseased cows would probably not be tested. The results of the test, as conducted, are shown in table 3.

A 90% accuracy of diagnosis was obtained in reference to the 196 "known pregnant cows". On the basis of including all animals, the percent accuracy of the test relative to the 125 "known nonpregnant cows" was 84. On the basis of the preliminary trials, the six cows which were in estrus when tested should have given a positive reaction, and also, perhaps, should have the three cows with cystic ovaries. Removal of these nine cows

TABLE 4. PERCENT OF ACCURACY BY MONTH OF GESTATION FOR COWS GIVEN THE "VAGINAL RESPONSE TO OXYTOCIN TEST"

Month of gestation	Total no. of cows	Pregnant cows tested as pregnant	Pregnant cows tested as nonpregnant	Percent of accuracy
0–15 days	18	15	3	83
1	10	9	1	90
1½	6	4	2	67
2	26	24	2	92
2½	11	10	1	91
3	20	18	2	90
3½	12	8	4	67
4	17	14	3	82
4½	10	9	1	90
5	29	29	0	100
5½	8	8	0	100
6	16	15	1	94
6½	4	4	0	100
7	7	7	0	100
7½	4	4	0	100
8	5	5	0	100
8½	3	2	1	67
Total	206	185	21	

from the data resulted in a 92% accuracy of diagnosis. The number of cows per breed was too small to justify comparisons between breeds as to their reaction to the test.

The vaginal response to oxytocin test appeared to be quite accurate even during the earlier stages of pregnancy, table 4. The three "pregnant cows tested as nonpregnant" listed for the month of gestation, 0–15 days were tested 3, 10, and 12 days after being bred, respectively. Of the 15 "pregnant cows tested as pregnant" in the 0–15 days class, 13 were diagnosed pregnant by a veterinarian using the rectal palpation technique. The other two were not tested manually but did not return to heat for a number of cycles.

Discussion. The test for pregnancy described and used in this present study was based primarily on a few previous reports. Evans and Miller

(1936) found that pituitrin (oxytocin) when injected into an animal would cause a spasm of the uterus. By use of a balloon inserted into the uterus, it was found that the organ responded most when the cow was in estrus, and that a few hours after ovulation the uterus became less responsive and remained relatively refractive until the onset of the next estrus period. Cupps and Asdel (1944) reported similar results concerning uterine response, especially during estrus.

Dukes (1933) indicated that oxytocin caused a greater contraction of uterine muscle in pregnant than nonpregnant cows. Petrych (1936) injected posterior pituitary extract into the jugular vein and then palpated the cervix via the vagina. In pregnant cows, a marked constriction and stiffening of the cervix could be detected by palpation within 1.0 to 2.5 minutes post-injection. Contractions were not detected in nonpregnant cows.

Studies by Grollman (1941) on the action of smooth muscles stimulated by oxytocin indicated that the vaginal muscles would produce contractions of sufficient amplitude to be of value for diagnosing pregnancy.

The technique described in this present study appears to have some advantages. Relative to the method used by Petrych (1936), insertion of the deflated balloon and catheter into the vagina is more easily accomplished, especially in small females, than entering the hand and forearm for purposes of palpation of the cervix. It is much easier to insert a balloon into the vagina than into the uterus as was done by Evans and Miller (1936). The apparatus is light in weight, portable, and easy to use. Parts requiring disinfection may be treated easily. The apparatus could be made more useful if a manometer of a smaller total range but with finer gradations of scale were used. A squeeze-bulb pump and air release valve of a type used with a blood sphygmomanometer would be an improvement over the hand pump and release valve pictured in figure 1.

The reaction of a cow in estrus is sufficiently similar to a pregnant cow as to cause an inaccurate diagnosis of pregnancy. Usually, however, the herdsman should know which cows are in estrus or have just passed from estrus and these cows should be exempt from the test. One possible improvement in the technique would be to exclude from testing any cow which had been in estrus only a very few days previous to testing; however, observations indicated that effects from estrus disappeared after about 24 hours.

The lower percent accuracy found at 3.5 to 4 months of pregnancy may have been a matter of chance but may indicate an alteration of endocrine balances at that time of pregnancy.

Summary

A method for the diagnosis of bovine pregnancy, especially in the early stages, was described. It is based on the indirect measurement of the contraction of vaginal muscles by means of a balloon inflated in the vagina and connected to a manometer in response to an intravenous injection of 30

U.S.P. units of oxytocin. Increases over initial pressure of approximately 10 mm. Hg about 3–4 minutes after injection are found when cows are pregnant. No or very little response was obtained from nonpregnant cows. If a response did occur, it was erratic. Cows in estrus respond like pregnant cows, whereas cows in other phases of the estrous cycle respond like nonpregnant cows.

A total of 321 cows were tested by means of the described technique. A 90% accuracy of diagnosis of pregnancy was found even in the early stages of pregnancy.

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RELATIONSHIP OF LIVER AND PLASMA CAROTENOID AND VITAMIN A CONTENT IN CATTLE AS AFFECTED BY LOCATION AND SEASON [1]

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THE importance of vitamin A to various phases of the livestock industry has been reported by many research workers. Many pathological conditions of unknown origin have been attributed to a deficiency of vitamin A. Watkins *et al.* (1950) stated that a vitamin A deficiency will develop in range cows on typical Western ranges only in times of prolonged drought. However, Riggs (1940) working with young cattle on diets devoid of carotene and vitamin A, reported depletion of vitamin A stores in as little as 46 days. Davis and Madsen (1941) indicated that in cattle vitamin A deficiency could be diagnosed by a blood analysis, but Bodansky and Markart (1951) found measurable amounts of vitamin A in rat plasma, although the liver was entirely depleted. Although some specie differences exist, Almquist (1952) working with chicks, rats, lambs and cattle found that a logarithmic relationship existed between plasma and hepatic vitamin A.

Since 1940 many workers have tried to establish either a direct or an indirect relationship between plasma and hepatic vitamin A levels. Braun (1945) found a tendency toward a direct relationship between vitamin A stores and plasma vitamin A levels only when the former fell below normal levels. Frey *et al.* (1947) postulated that serum levels and body stores are controlled by different mechanisms, and relationship ceases to exist when dietary intake exceeds 100 I.U. per lb. of body weight. The level of 20 mcg.% of vitamin A in plasma was established by Hoefer and Gallup (1947) as the critical point above which relationship ceased to exist in sheep. Almquist (1952) found plasma vitamin A concentration was linearly related to the logarithm of the liver vitamin A concentration. This functional relationship has been supported under conditions of fixed dietary vitamin A intake by Rousseau *et al.* (1958) and others.

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The present study was undertaken to determine the relationship of hepatic and plasma carotenoids and vitamin A concentrations of cattle at several locations in the State of Washington during different seasons.

Procedure

A total of 90 cows from nine different areas were selected to obtain a cross section of conditions under which cattle are produced in Washington. These areas are typical of much of the Northwestern range. The cattle selected were believed to be a random sample of the cattle in each herd. Samples of blood and liver were collected at three-month intervals, four seasons of the year—during the fall of 1956, and winter, spring, and summer of 1957.

The aspiration biopsy technique of Erwin *et al.* (1956) was used in obtaining liver tissue. Plasma was obtained by centrifuging heparinized jugular venous blood on location. All samples were immediately frozen with Dry ice and kept frozen until analyzed. Carotenoids and vitamin A were determined in the plasma by the Kimble (1939) procedure and in the liver by the method of Gallup and Hoefer (1946). Feed samples were not analyzed owing to the wide range of feed sources available to the cattle.

Results and Discussion

The chemical analyses of plasma and liver showed average yearly values comparable with those reported by other workers in the field. An average of 151 mcg. of vitamin A per gram of liver confirms the normal expected level reported by Moore and Sharman (1951). The average vitamin A found in blood plasma, 45 mcg. per 100 ml., was somewhat below the range reported by Lelesz (1939) of 51–269 mcg. of vitamin A per 100 ml., but supported the findings of Wheeler *et al.* (1957). The average carotenoid content was 15 mcg. per gram of liver tissue and 6 mcg. per ml. of plasma. Ranges for vitamin A were from 16–420 mcg. per gram of liver and from 6–106 mcg. per 100 ml. of plasma. The ranges of carotenoids, 2–41 mcg. per gram of liver and 0.4–13 mcg. per ml. of plasma, were also extremely wide as would be expected owing to the varied and uncontrolled intake. Tissues of some cattle were sometimes borderline in vitamin A and carotenoid content, but vitamin A deficiency syndromes in cattle were not seen at any location in any season.

As location, season and weather conditions are interrelated, these data were subjected to analysis of variance of randomized complete block design (Snedecor, 1956). This type of design allows the separation of the season x location interaction, which proved to be highly significant ($P<0.01$) for liver vitamin A. Seasonal variations of liver carotenoids and vitamin A were highly significant. Both season and location variations of plasma carotenoids and vitamin A were significant at the 1% level.

The use of "Duncan's Multiple Range Comparison" (with "Kramer's Modification" in case of unequal numbers) permitted a better comparison of means than is possible by the use of LSD. In plasma carotenoids and vitamin A, samples taken in the spring and summer were significantly higher than those taken in the fall and winter; fall samples were significantly higher than winter samples. Liver samples taken in the fall and summer were significantly higher in vitamin A than were those taken in the winter and spring, with little variation between the latter. In contrast,

TABLE 1. CAROTENOID AND VITAMIN A CONTENT OF BLOOD PLASMA AND LIVER OF CATTLE AT NINE LOCATIONS

Location	1	2	3	4	5	6	7	8	9	Av.
					Plasma, carotenoids, mcg./ml.					
Fall	4.67	8.28	6.10	7.74	5.80	4.67	5.86	4.99	2.69	5.65
Winter	0.86	5.96	3.12	3.88	3.46	2.97	4.63	5.69	w	3.82
Spring	6.92	7.91	3.52	7.67	5.75	5.62	8.79	10.45	8.53	7.39
Summer	5.63	8.28	9.12	9.84	5.22	10.42	7.19	3.14	9.98	8.28
Av.	4.52	7.61	5.47	7.28	5.06	5.92	6.62	6.07	7.07	6.29
					Liver, carotenoids, mcg./gm.					
Fall	12.48	13.72	13.44	14.03	13.69	11.36	13.38	16.99	13.06	13.57
Winter	8.61	12.02	9.40	9.42	7.34	10.84	10.53	11.13	w	9.98
Spring	19.81	20.00	17.37	18.45	19.69	20.67	21.57	18.09	23.97	19.82
Summer	12.68	15.19	17.86	12.00	18.04	16.42	13.42	4.94	37.16	16.31
Av.	13.40	15.23	14.51	13.48	14.69	14.82	14.73	12.79	24.73	14.92
					Plasma, vitamin A, mcg./100 ml.					
Fall	31.78	23.04	35.91	41.21	30.27	39.66	26.55	32.57	27.48	32.05
Winter	21.19	42.90	32.82	49.85	30.20	48.40	35.52	55.17	w	40.53
Spring	41.50	44.74	48.10	50.64	37.37	38.34	72.14	90.76	57.57	53.57
Summer	44.61	52.07	37.13	51.99	47.98	73.10	64.77	63.23	44.89	55.03
Av.	34.77	40.69	38.49	48.42	38.96	49.88	49.75	60.43	32.49	45.30
					Liver, vitamin A, mcg./gm.					
Fall	137.05	126.26	232.72	149.69	254.63	136.91	194.91	172.92	190.96	177.34
Winter	109.41	132.53	152.01	155.13	163.62	129.66	145.81	131.65	w	138.21
Spring	98.06	139.75	166.30	141.56	175.18	110.16	140.98	124.32	125.25	132.57
Summer	95.25	179.41	214.98	156.70	245.70	124.79	196.63	90.68	167.94	155.87
Av.	109.94	144.47	191.50	150.77	207.53	125.38	169.58	129.89	161.38	151.00

* Winter samples were not taken for location 9.

each season significantly affected the liver carotenoid level. Samples taken during the summer had the highest liver carotenoid level, followed by samples taken in the spring, fall, and winter, respectively ($P<0.01$).

Simple correlations were calculated on plasma and liver tissue levels of carotenoids and vitamin A, herd condition score, and temperature means. These correlations were calculated on a yearly basis and for each season to determine if certain relationships were greater in certain seasons than others. Herd condition score was an arbitrary, visual evaluation of the cattle as to condition and general health.

Plasma carotenoids were significantly related to liver carotenoids, plasma vitamin A, and temperature. The plasma carotenoids relationship to liver carotenoids and plasma vitamin A was most significant during the winter;

somewhat less in the spring; only slightly related during the summer; and, unrelated throughout the fall.

Liver carotenoids were not related to liver vitamin A, but showed a relationship to plasma vitamin A and temperature ($P<0.05$). The correlation of liver carotenoids with plasma vitamin A varied throughout the year, from highly significant during the winter, little or no relationship during the spring and fall, to a highly significant negative correlation through the summer.

Plasma vitamin A, although significantly related to temperature, varied throughout the year from a highly significant relationship during the winter and little relationship during the summer and spring to a highly significant negative relationship during the fall. The effect of temperature on vitamin A and carotenoids may occur as stress due to cold as suggested

TABLE 2. SUMMARY OF SIMPLE CORRELATION COEFFICIENTS CALCULATED ON A YEARLY BASIS

Item	Plasma carot.	Liver carot.	Plasma vit. A	Liver vit. A	Cond. score	Mean temp.
Plasma carotenoid	1.00	0.66**	0.58**	0.23	0.27	0.56**
Liver carotenoid		1.00	0.35*	0.28	0.23	0.39*
Plasma vitamin A			1.00	0.10	0.25	0.35*
Liver vitamin A				1.00	0.45**	0.50**
Conditional score					1.00	0.53**
Mean temperature						1.00

** $P<0.01$.
* $P<0.05$.

by Ershoff (1950) from his tests with rats or indirectly through stimulated plant growth. Blinco and Brody (1955) have shown that temperature above the comfort zone reduces thyroid activity of cattle. Temperature changes may then indirectly control carotene absorption and conversion. There was no apparent relationship between plasma vitamin A and liver vitamin A, regardless of the season. The fact that plasma vitamin A levels were no index of liver vitamin A stores tends to support the findings of Braum (1945), Frey *et al.* (1947) and Hoefer and Gallup (1947). Logarithmic and arithmetic comparisons between plasma and liver vitamin A failed to establish a relationship between the two under highly variable conditions in which the intake was not controlled.

Summary and Conclusions

Blood samples and liver biopsy samples were taken from cattle in nine locations in the State of Washington and analyzed for carotenoids and vitamin A. There was an average of 10 animals per location for each of the

four seasons of the year. None of the animals showed vitamin A deficiency symptoms.

Plasma levels of carotenoids and vitamin A showed highly significant ($P<0.01$) differences for both season and location. The seasonal influence on carotenoid and vitamin A content of the liver was also highly significant. The vitamin A stores in the liver were significantly affected by season x location interaction ($P<0.01$).

Apparently, hepatic stores of vitamin A cannot be determined by plasma analysis alone. Plasma carotenoids were related significantly ($P<0.01$) to liver carotenoids and plasma vitamin A. Liver carotenoids were related to plasma vitamin A ($P<0.05$) on a yearly basis; however, during times of depletion of vitamin A, the relationship increased ($P<0.01$).

Logarithmic and arithmetic correlations failed to establish a relationship between plasma and liver vitamin A under these highly variable conditions and uncontrolled intake.

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ASSOCIATIONS AMONG CONFORMATION SCORES, AMONG BODY MEASUREMENTS AND THE RELATIONS BETWEEN SCORES AND MEASUREMENTS IN YEARLING STEERS[1, 2]

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THE study of form and function and relations between them are of particular importance in developing and evaluating selection criteria for beef cattle. Investigations involving feeder and slaughter cattle have included studies of association among conformation scores, among body measurements and among production factors as well as relations between these factors and between them and consumer preference. Few, if any, studies have included work on all phases simultaneously utilizing a single group of animals. An experiment designed to provide information of this type is reported in two companion papers the first of which deals with conformation scores and body measurements.

Experimental Design

An attempt was made to purchase ten yearling steers of each of five feeder grades—Choice, Good, Medium, Common and Inferior—in October of each year for two years. There was no selection of animals within grades. Examination of the teeth indicated that the steers were between 15 and 21 months of age. The actual numbers classified by grade and year are shown in table 1. The majority of the steers were of predominantly Hereford breeding. It was found, however, that in order for a steer to grade Inferior it was necessary that it exhibit evidence of dairy breeding, and a steer exhibiting evidence of dairy breeding would not be graded higher than Common. Consequently, some of the steers grading Common and all of them grading Inferior showed evidence of some dairy breeding, mostly Holstein. There is no way to separate "breed" and "grade" effects in these

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[2] The original data and detailed tabular material have been published separately as Nevada Agricultural Experiment Station Technical Bulletin 204, 1959, Relations Among Conformation Scores, Body Measurements and Production Factors of Yearling Steers.

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TABLE 1. NUMBER OF EXPERIMENTAL ANIMALS BY YEAR AND FEEDER GRADE

Year	Feeder grade					
	Choice	Good	Medium	Common	Inferior	Total
1954	7	12	12	9	7	47
1955	10	10	9	10	12	51
Total	17	22	21	19	19	98

data. It is doubtful, however, that this results in serious error. The steers were purchased in the open market in such a manner that prices paid reflected current Nevada prices.

The steers were assembled at the experimental farm as purchased, and allowed several weeks to become acclimated to the ration, pens and feeder. Immediately prior to the start of the experimental period, the animals were measured and scored. Body measurements included weight, height at withers, height at hooks, heart girth, round (horizontal patella to patella), body length, width of hooks and width of chest. A single weight was taken to the nearest 5 lb. following a 12-hour shrink. The other measurements were taken to the nearest 0.1 in. as described by Kidwell (1955).

Each animal was assigned a numerical score for each component of total score. The components are as follows (numbers indicate the range in numerical value for each component): General type and appearance, weight for age, 0–10; thickness of body, 0–10; depth of body, 0–10; smoothness of body, 0–5; natural fleshing, 0–10; head, 0–5; neck and shoulders, 0–5; crops and ribs, 0–10; loin and back, 0–10; rump, 0–5; round, 0–10; legs and feet, 0–10. The numerical scores used for each descriptive grade designation are shown in table 2. The standard slaughter

TABLE 2. U.S.D.A. DESCRIPTIVE GRADES WITH NUMERICAL SCORES

Descriptive feeder grade	Numerical score	Descriptive slaughter grade	Numerical score	Descriptive carcass grade	Numerical score
Fancy	92–100	Top Prime	98–100	Top Prime	99
Choice	83–91	Av. Prime	95–97	Av. Prime	96
Good	74–82	Low Prime	92–94	Low Prime	93
Medium	65–73	Top Choice	89–91	Top Choice	90
Common	56–64	Av. Choice	86–88	Av. Choice	87
Inferior	47–55	Low Choice	83–85	Low Choice	84
		Top Good	80–82	Top Good	81
		Av. Good	77–79	Av. Good	78
		Low Good	74–76	Low Good	75
		Top Commercial	71–73	Top Commercial	72
		Av. Commercial	68–70	Av. Commercial	69
		Low Commercial	65–67	Low Commercial	66
		Top Utility	62–64	Top Utility	63
		Av. Utility	59–61	Av. Utility	60
		Low Utility	56–58	Low Utility	57

grade was not in use at the time the experiment was initiated. This is a slightly modified form of the grading system developed by Guilbert and Hart (1951). It was noted that scorers tended to use only the center of the available range for each item. The descriptive feeder grade assigned each animal was determined on the basis of its total numerical score. Numerical slaughter grades were assigned in the same manner. Descriptive carcass grades were assigned by a U.S.D.A. grader and the numerical score determined from the descriptive grade. The midpoint for each carcass grade was used. A top good carcass, for example, was given a numerical grade of 81.

During the experiment the steers were individually fed in small pens twice a day, but were allowed to run together in groups of 10 to 12 at other times. The feeding periods were at 12-hour intervals and of approximately 2 hours' duration. Water was not available during the feeding period but was available at all other times. The steers appeared to adjust to this situation rather quickly. The ration consisted of a concentrate (69% rolled barley, 20% beet pulp, 10% cottonseed meal, 1% salt) and grass and clover hay. Each animal was allowed all it would eat, but an attempt was made to maintain a 1:1 hay to concentrate ratio. Each steer was started on 6 lb. of hay and 6 lb. of concentrate per day. Feed allowance was continuously adjusted according to individual appetite and consumption. Hay and concentrate consumption ranged from 10 to 16 lb. of each per day when the steers were on full feed.

Half the animals of each feeder grade were randomly selected and fed for approximately 90 days, the remainder for approximately 150 days.

Immediately prior to slaughter at a local packing plant, the steers were scored and measured as before. The carcasses were chilled for 48 hours and the right side of each taken to a local processing plant where the carcass data were completed. These data include score, dressing percent, percent shrink, round, loin, rib, chuck, plate and percent physically separable bone, muscle and fat in the 9–10–11 rib. The five wholesale cuts were those used by the processor. Dressing percent was determined on the basis of shrunk live weight and 48-hour chilled carcass weight. Percent of the wholesale cuts was based on the right side only. Economic data include feeder price, slaughter price, carcass price, carcass weight $\times$ price and the sum of the weights of each wholesale cut $\times$ price. Each of the prices used was assigned by an appropriate buyer and reflected current Nevada markets. Gain data include average daily gain, lb. of hay per lb. of gain, and lb. of grain per lb. gain. The carcass data, economic data and gain data are referred to collectively as "production factors".

Circumstances beyond experimental control prevented the slaughter of all animals in a given group on the same day. Except for one group, the interval was small. Average daily gain was computed accordingly. The 7–8 rib cut was obtained from 49 of the last (1955–56) group of steers for organoleptic tests.

Results and Discussion

Relations Among Conformation Scores. This phase of the experiment was designed to study the relations among the components of a particular score card at several times, and the effects of fattening on scores of yearling steers. Simple correlations among the components of feeder score were computed.

Correlations involving feet and legs are low or insignificant. This arises from the fact that only rarely did the grader penalize a steer for poor feet and legs. It was noted that grading on this component would be more severe for breeding animals. The remaining correlations range from 0.47 to 0.96, most of them being of the order of 0.85. Correlations among components of slaughter score were computed and found to be quite similar to those for feeder scores. It is a well-known theorem of statistics that the variance of a sum is equal to the sum of the variances plus twice the sum of the covariances between them. Since total feeder and slaughter scores are a sum, their variance was expressed in this way. Each component accounts for less than 2% of the total variation. Nearly 88% of the variation is due to covariances among the components. This, coupled with the high correlations among the components, suggests that total score alone provides as adequate an evaluation of conformation as does consideration of all the items of the score card. The grader may well take the various items into account in arriving at an over-all evaluation; but, once this is reached, all items tend to be evaluated so as to verify the over-all score.

Knapp *et al.* (1939) studied the accuracy of scoring 11 components of total score on beef Shorthorn cows and heifers. Gifford *et al.* (1951) and Brown *et al.* (1953) studied classification scores of breeding beef animals, with particular emphasis on agreement between judges, repeatability of judges, and the cause of variation in conformation scores. These findings tend to support and extend those of previous investigations.

In order to estimate the repeatability of scores, the correlations between the corresponding components of feeder and slaughter scores were computed. Except for feet and legs, which was zero, these were of the order of 0.65. Johnson and Lush (1942) found repeatability of scores of Holstein cows to be 0.56. Hyatt and Tyler (1948) found comparable figures of 0.82 and 0.86 in the Ayrshire breed. Gifford *et al.* (1951) reported estimates of 0.31 to 0.58 for Hereford cows. Since the scores of this study were assigned at the beginning and end of a fattening period, the situation may not be directly comparable to those cited. However, the repeatability estimates are similar.

Relations Among Body Measurements. This phase of the experiment was designed to investigate relations among body measurements taken immediately prior to fattening, subsequent to fattening and immediately prior to slaughter, and of changes during fattening.

Many investigators have used body measurements in studies of growth

and form in beef cattle. Most of this literature has been reviewed by Kohli, *et al.* (1951) Yao, *et al.* (1953) and Kidwell (1955).

The mean, standard error and coefficient of variation of each measure and ratio are presented in table 3. Although the means are different from those observed for fat calves (Kidwell, 1955), except for body weight the standard errors and coefficients of variation are quite similar. The standard error and coefficient of variation for weight were much smaller in these data. However, the data support the suggestion that heart girth is a more suitable measure of size than is weight for studies of growth and form in beef cattle.

All simple correlations among feeder measurements and ratios were

TABLE 3. MEAN, STANDARD ERROR, AND COEFFICIENT OF VARIATION OF BODY MEASUREMENTS AND RATIOS

	Feeder			Slaughter					
				Period I			Period II		
Measures	Mean	Standard error	C.V. percent	Mean	Standard error	C.V. percent	Mean	Standard error	C.V. percent
Weight, lb.	741.0	9.20	12.29	898.0	13.66	10.86	989.0	16.38	11.35
Height at withers, in.	43.8	0.24	5.46	47.1	0.34	5.16	47.9	0.37	5.28
Height at hooks, in.	46.6	0.25	5.26	49.9	0.37	5.30	50.8	0.41	5.60
Chest width, in.	13.8	0.13	9.18	15.7	0.19	8.64	16.4	0.19	8.04
Hooks width, in.	16.1	0.12	7.24	17.4	0.13	5.34	18.2	0.13	4.75
Heart girth, in.	63.7	0.38	5.85	70.6	0.45	4.59	72.7	0.54	5.11
Round, in.	39.2	0.36	9.04	42.0	0.35	5.89	41.4	0.32	5.22
Body length, in.	53.1	0.28	5.24	55.4	0.38	4.90	55.5	0.38	4.66
Ht. withers x 100 / Heart girth	68.8	0.39	5.68	66.7	0.45	4.79	65.8	0.48	4.96
Length x 100 / Heart girth	83.3	0.54	6.46	78.6	0.55	5.03	76.4	0.54	4.88
Chest width x 100 / Heart girth	21.6	0.16	7.12	22.2	0.18	5.75	22.5	0.18	5.40

computed. In general, those correlations relating weight, heart girth and chest width to the other measures and ratios were of the order of 0.50. The others were low or insignificant. These correlations are quite similar to those found among measures taken on fat calves prior to slaughter (Kidwell, 1955). Correlations among slaughter measurements were also computed. They were quite similar to those observed among the feeder measures. Many of these correlations are of the type Pearson (Snedecor, 1956, p. 188) called "spurious" because of their relation to general size, and must be interpreted accordingly.

The results are, in general, in agreement with those of previous studies. Weight is associated in a fairly high degree with the remaining measurements, and to a lesser degree with the ratios. Height at withers and height at hooks are closely associated. Chest width and hooks width are also closely associated. It seems, however, that both might be useful since width of hooks is primarily a measure of skeletal development, while width

of chest also measures muscular and fat development. The round measure is not highly associated with the other measures, and there is a small, negative correlation between round measure and percent round. Relations involving body length are of intermediate value. The generally low correlations of ratios with measurements, particularly chest width × 100/heart girth, suggest their utility in studying form.

Among the correlations between corresponding feeder and slaughter measures, those for weight, height at withers, height at hooks and heart girth are quite high. The remaining ones are not.

Mean changes as influenced by feeder grade and length of feeding period were studied. Significant period differences were observed for weight, height at withers, height at hooks, width of hooks, heart girth and the two ratios, length × 100/heart girth and chest width × 100/heart girth. No grade × period interactions were observed. A grade difference was observed for chest width. It appears that chest width is indicative of fatness, which is closely associated with grade. No other grade differences were observed. Round, body length, and the ratio height at withers × 100/heart girth did not show a period difference in changes.

Lush (1928) studied changes in body measurements of steers during intensive fattening. He found the greatest increase in width followed by circumference, width of pelvis region, body depth, body length, height and head measurements in decreasing order. In these data, the greatest increase was in heart girth, followed by height, round, length and width measurements. These cattle were generally younger and not as highly fattened as those considered by Lush. It appears that there was relatively more bone and muscle growth and less fat deposition in these animals. Lush found age to be an important factor in determining changes during fattening.

It is of interest to note that with increasing fatness heart girth increases at a greater rate than height at withers and body length, but at a slower rate than chest width. It follows that with increased fattening a steer tends to assume a blockier, more compact, appearance. This may account, at least in part, for the generally higher grades assigned fatter animals.

Relations Between Conformation Scores And Body Measurements. Correlations between feeder measures and feeder scores and between feeder measures and slaughter total score were computed. The only feeder measures importantly related to scores, feeder or slaughter, are height at withers, height at hooks, chest width, and the two ratios of height at withers × 100/heart girth, and chest width × 100/heart girth. Score for feet and legs does not appear to be related to any of the measures.

The similarity of the estimated correlation coefficients between each measure and total score, and those between the measure and each component of total score, suggests that the latter correlations are due to their relation to total score. None of the partial correlations, holding total score constant, was significant.

Simple correlations between slaughter measures and slaughter scores

proved to be quite similar to those observed for feeder measures. They are also similar to those of other investigators (Black *et al.*, 1938; Kidwell, 1955). Partial correlations between measures and components of total score, with total score held constant, were all insignificant. None of the correlations involving score for feet and legs was significant.

Since correlations involving height at hooks appeared to be higher than those involving height at withers, the ratio of feeder height at hooks $\times$ 100/heart girth was computed and its correlation with feeder and slaughter total score determined. These were —.63 and —.53, respectively. This, coupled with the high correlation between height at hooks and height at withers, clearly suggests that only one of the height measures is required and that height at hooks is preferable.

Neither feeder nor slaughter weight nor heart girth was associated with feeder or slaughter grade. This is contrary to the findings of Kidwell (1955) with fat calves. The correlations involving width of chest and width of hooks are generally low but, for the most part, significant. Kidwell (1955) found width of chest to be most highly correlated with slaughter grade of fat calves. Correlations involving round, body length, and the ratio body length/heart girth were either insignificant or too low to be of practical value.

The existence of differences among the means of each feeder measurement classified by feeder grade were determined by analysis of variance with single classification, as described by Snedecor (1956). There is evidence of differences for height at withers, height at hooks, chest width, height at withers/heart girth, and chest width/heart girth. There are ten possible differences among the five means. These were tested for significance by the method of Tukey (1953) as described by Snedecor (1956). Significant differences are presented in table 4. None of the measures or ratios separated Choice and Good, Good and Medium, or Common and Inferior. Height at withers and height at hooks separated Medium and Common. It appears that feeder grade is not determined to a large extent by the measures or ratios studied.

Analysis of variance of a 5 $\times$ 2 table with disproportionate subclass numbers as described by Snedecor (1956, page 382) was used to analyze the five feeder grades and two length-of-feeding periods (90 and 150 days). There were no significant grade $\times$ period interactions. The additional 60 days of feeding did not increase significantly body length or round, although there was an average increase of 93.5 lb. in weight. The ratio of chest width to heart girth did not seem to change during the last 60 days on feed.

Significant grade differences are presented in table 5. In no case were all 10 possible differences significant. The ratio of height at withers to heart girth resulted in eight significant differences. However, it failed to separate Choice and Good and to distinguish Common and Inferior. It appears that animals of different feeder grades will not differ greatly at slaughter with

TABLE 4. ESTIMATED DIFFERENCES AMONG FEEDER MEASURES DUE TO FEEDER GRADES

Feeder measures	Differences between feeder grades[a]									
	Choice-Good	Choice-Medium	Choice-Common	Choice-Inferior	Good-Medium	Good-Common	Good-Inferior	Medium-Common	Medium-Inferior	Common-Inferior
Ht. withers	—	—	−2.8*	−3.3*	—	—	−2.1*	−2.2*	−2.7*	—
Ht. hooks	—	—	−3.1*	−3.7*	—	−2.3*	−2.9*	−2.6*	−3.2*	—
Chest width	—	—	+1.1*	+1.3*	—	+1.2*	+1.4*	—	—	—
Ht. withers x 100 / Heart girth	—	−3.8*	−6.0*	−6.4*	—	−3.9*	−4.3*	—	—	—
Chest width x 100 / Heart girth	—	—	—	+1.7*	—	+1.4*	+1.9*	—	+1.4*	—

[a] Nonsignificant differences omitted.
* Significant at 0.05 level.

TABLE 5. ESTIMATED DIFFERENCES AMONG SLAUGHTER MEASURES DUE TO FEEDER GRADES

Slaughter measures	Differences between feeder grades[a]									
	Choice-Good	Choice-Medium	Choice-Common	Choice-Inferior	Good-Medium	Good-Common	Good-Inferior	Medium-Common	Medium-Inferior	Common-Inferior
Ht. withers	—	—	−3.3**	−3.6**	—	−2.6**	−2.9**	−3.0**	−3.4**	—
Ht. hooks	—	—	−3.0**	−4.1**	—	−2.6**	−3.6**	−3.0**	−4.1**	—
Round	—	—	+1.9**	+1.9**	—	—	—	—	—	—
Ht. withers x 100 / Heart girth	—	−2.8**	−5.4**	−5.9**	−1.7*	−4.4**	−4.9**	−2.7**	−3.2**	—
Chest width x 100 / Heart girth	—	—	—	+1.0**	—	—	+1.0*	—	—	+0.8*

[a] Nonsignificant differences omitted.
* Significant at 0.05 level.
** Significant at 0.01 level.

respect to the measures or ratios studied. The results for the height at withers/heart girth ratio suggest that definitive measures or ratios might exist.

The influence of slaughter grade on slaughter measures was also studied using a 5 x 2 table with disproportionate subclass numbers to account for the five grades and two periods. Significant period differences were observed for weight, height at withers, height at hooks, width of hooks and the ratio length $\times$ 100/heart girth. Although height at hooks increased with decreasing grade for both periods, the longer-fed animals showed a mean period difference of 1.9 inches, indicating the extra finish placed some of the taller animals into a higher grade.

A grade X period interaction was observed for slaughter round measure. The interaction apparently is due to an exceptionally large mean of the Utility grade, Period II steers.

Significant grade differences are shown in table 6. The measures and ratios used did not separate all 10 possible grade combinations. The ratio of height at withers to heart girth showed significant differences between all grades except Commercial and Utility, and Utility and Cutter.

The regression of feeder total score, Y_1, on feeder height at hooks $\times$ 100/heart girth, X_1, and feeder chest width $\times$ 100/heart girth, X_2, was computed. These two ratios were selected because of their high zero order correlations with total score and the low correlations between them. Other measures highly associated with total score were not used because of their high association with X_1 and X_2. The multiple regression equation is:

$$\hat{Y}_1=126.9-1.6X_1+3.0X_2 \quad R^2=0.54$$

The partial regression coefficients differ from zero at the 1% significance level. The standard partial regression coefficients are of similar magnitude (−.6, 0.4). These two ratios account for 54% of the variation in total feeder score.

Inspection of the zero order correlations between feeder measures and slaughter total score, Y_2, led to a multiple regression involving feeder chest width $\times$ 100/heart girth, X_2; feeder height at hooks, X_3; and feeder height at withers $\times$ 100/heart girth, X_4. The multiple regression equation is:

$$Y_2=165.3+1.87X_2-1.52X_3-0.86X_4 \quad R^2=0.47$$

The partial regression coefficients differ from zero at the 1% significance level. The standard partial regression coefficients are 0.28, 0.37, and 0.33. These three variables account for 47% of the variation in slaughter score.

Similar analysis of slaughter measures and total slaughter score led to the multiple regression of slaughter score, Y_3, on slaughter height at hooks, X_5; slaughter height at withers x 100/heart girth, X_6; slaughter chest width $\times$ 100/heart girth, X_7. The multiple regression equation is:

$$\hat{Y}_3=181.16-0.71X_5-1.74X_6+2.04X_7 \quad R^2=0.59$$

The partial regression coefficients differ from zero at the 1% significance level. The standard partial regression coefficients are 0.20, 0.56, and 0.25. These three variables account for 59% of the variation in slaughter score.

TABLE 6. ESTIMATED DIFFERENCES AMONG SLAUGHTER MEASURES DUE TO SLAUGHTER GRADE

Slaughter measures	Differences between slaughter grade[a]									
	Choice-Good	Choice-Commercial	Choice-Utility	Choice-Cutter	Good-Commercial	Good-Utility	Good-Cutter	Commercial-Utility	Commercial-Cutter	Utility-Cutter
Ht. withers	—	−2.6**	−3.1**	−4.1**	−1.7*	−2.6**	−4.0**	—	—	—
Ht. hooks	—	−2.3**	−4.1**	−4.4**	—	−2.7**	−3.5**	—	—	—
Chest width	+0.9**	+1.1**	—	+2.3**	—	—	+1.6*	—	+1.6*	—
Hooks width	+0.7**	—	—	—	—	—	—	—	—	—
Heart girth	+2.9**	+2.1**	—	—	—	—	—	—	—	—
Ht. withers x 100 / Heart girth	−2.9**	−4.8**	−5.9**	−8.2**	−1.8*	−3.0**	−5.6**	—	−3.8*	—
Chest width x 100 / Heart girth	—	—	—	+2.3**	—	—	+2.4**	—	+2.1*	—

[a] Nonsignificant differences omitted.
* Significant at 0.05 level.
** Significant at 0.01 level.

These results are in general agreement with those of other studies relating body measurements to conformation scores (Black *et al.*, 1938; Bogart *et al.*, 1956; Brown *et al.*, 1956; Cook *et al.*, 1951; Hankins and Burk, 1938; Hultz, 1927; Hultz and Wheeler, 1927; Kidwell, 1955; Knapp and Cook, 1933; Yao *et al.*, 1953). Zero order correlations are either insignificant or too low to be useful. Correlations of ratios or other combinations of measures are similar. Multiple regression equations accounted for less than 60% of the variation in score. Multiple regression equations developed from data obtained from one group of animals have not been successfully applied to other groups (Kidwell, 1955). The multiple regression equations presented could not possibly serve as estimating equations or indices. Their chief utility is in demonstrating that each measure, in combination with the others, influences conformation score. The various discrete grades used failed to separate the measures or ratios into corresponding distinct groups. Brown *et al.* (1956) observed that the statement of Lush (1928), "In the geometrical sense the animal body is of such a complicated shape that any one or few measurements could approximate a description of it in only the crudest way", is quite appropriate. The results of this study are in accord.

It would, however, seem possible that several measurements or appropriate combinations of measurements, while not providing a detailed geometric description, might be sufficiently representative of the pertinent proportions to be closely associated with conformation score. It does not appear reasonable to believe that the judge carefully evaluates all the geometrical complexities in visually appraising an animal. It is more likely that each judge considers a few well chosen indicators which contribute to an over-all appraisal. These data indicate that the ratios of height at withers and height at hooks to heart girth are useful in determining proportions of height to total size. The ratio of chest width to heart girth appears indicative of width proportions. The measurement of body length or the ratio of length to heart girth appears to have no significance in evaluating length proportions. It appears that proportions of total length to total size are not important. It is possible that the ratio of various segments of body length to total length or total size are important. The ratio of length of rump to total length might be considered.

Summary and Conclusions

An experiment involving 98 steers was conducted over a 2-year period to investigate relations among conformation scores, among body measurements and between body measurements and conformation scores.

1. A single total score appears to be as useful in evaluating an animal's conformation as is a detailed score card evaluating various components.

2. Repeatability of scores from the beginning and end of the fattening period was between 0.50 and 0.76, except for score for feet and legs, which was insignificant.

3. Heart girth appears to be a more suitable measure of size than body weight for studies of growth and form.

4. The ratio chest width x 100/heart girth was not correlated with any of the other measures or ratios. Correlations of round and of body length with other measures or ratios were generally low. Correlations among the remaining measures were generally high. The correlations between measurements taken before and after fattening were high for weight, height at withers, height at hooks, chest width, hooks width, heart girth, and the ratio height at withers $\times$ 100/heart girth, and low for the remaining measures and ratios.

5. The greatest increase in measures and ratios during fattening was in heart girth, followed by height, round, length, and width measurements.

6. Most of the simple correlations between body measures and conformation score were low or insignificant.

7. None of the measurement means were separated into distinct groups by either feeder or slaughter grade.

8. Multiple regression equations of score on various measures and ratios accounted for 47 to 59% of the variation in score.

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RELATION OF PRODUCTION FACTORS TO CONFORMATION SCORES AND BODY MEASUREMENTS, ASSOCIATIONS AMONG PRODUCTION FACTORS AND THE RELATION OF CARCASS GRADE AND FATNESS TO CONSUMER PREFERENCES IN YEARLING STEERS,[1, 2]

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GENETIC improvement of beef cattle has long been largely contingent upon selection criteria evaluated on the basis of visual appraisal. Many animal husbandmen, breeders and producers believe it is possible to predict accurately the rate and economy of gain, desirability of carcass traits, economic value and transmitting ability of an animal by means of visual appraisal. Relative economic value of virtually all cattle is determined accordingly. The literature rather clearly indicates that there may not be an association between conformation score and subsequent rate and economy of gain. The evidence with respect to score at different times is contradictory. There appears to be a relation between slaughter grade and carcass grade which may be due to their common association with degree of fatness. The literature concerning the relations between body measurements and production factors in beef cattle has been reviewed by Yao *et al.* (1953), White and Green (1952), Cook *et al.* (1951) and Kohli *et al.* (1951). These relations have generally been too low to be of practical value. Lindholm and Stonaker (1956) have studied the relative economic importance of traits affecting net income in beef cattle.

This paper presents an analysis of the relation of selected production factors to conformation scores and body measurements, associations among the production factors and the relation of carcass grade and fatness to consumer preference. A companion paper (Ternan *et al.*, 1959) described the experimental design and observed traits and presents an analysis of

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[2] The original data and detailed tabular material have been published separately as Nevada Agricultural Experiment Station Technical Bulletin 204, 1959, Relations Among Conformation Scores, Body Measurements and Production Factors of Yearling Steers.

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association among conformation scores, among body measurements and the relations between body measurements and conformation scores.

Results and Discussion

Relations Between Conformation Scores and Production Factors. Only two of the correlations between the components of feeder score and the gain data are significant, and they are too low to be of any value. These data support results of other investigators and warrant the conclusion that conformation score is not indicative of subsequent rate or economy of gain.

Simple correlations between the components of feeder score and a given trait and those of total feeder score and that trait are quite similar. The correlations between the component of feeder score and carcass grade, for example, are all of the order of 0.60. This suggests that the relation involving the components is the result of their common relation to total score. Partial correlations, with total score held constant, were all insignificant. A single total score is adequate to describe the merit of a feeder steer. These correlations suggest that feeder grade is related to carcass grade (0.63) and, to a lesser extent, dressing percent (0.43). Correlations between feeder score and percent of the wholesale cuts are low or insignificant, except that higher-grading animals tend to have less round. These data suggest that feeder grades are not indicative of the percent of the various wholesale cuts. The data also indicate that higher-grading feeder steers will produce a carcass with a smaller proportion of muscle, and a higher proportion of fat.

The correlations of feeder grade with feeder slaughter and carcass prices are 0.92, 0.75 and 0.35, respectively, and illustrate the influence of conformation score in determining economic value. The latter correlation is lower than expected in view of the relation between feeder score and carcass grade.

There appears to be no relation between slaughter score and previous rate or economy of gain. Except for body depth, none of the scores is related to percent shrink. Score for legs and feet bears very low or insignificant relation to any of the carcass traits. Partial regression analysis indicates that total score alone is as accurate as the score for the various components of total score.

Slaughter score is closely associated with carcass score, the coefficient of determination being 0.61. Carcass score is also positively associated with dressing percent. In a fat-constant population, the correlation between slaughter score and carcass grade is 0.49. It would appear that factors other than percent fat are important in determining this relation.

The relations between slaughter score and percent of the wholesale cuts are of the same order but higher than the relations of feeder score to these traits. Higher-grading slaughter steers yield relatively less round, bone and muscle, but a higher proportion of loin, rib, and fat. The cor-

TABLE 1. MEANS OF THE PRODUCTION FACTORS CLASSIFIED BY FEEDER GRADE AND FEEDING PERIOD

Item	Period I Feeder grade					Period II Feeder grade					Period mean diff.[a]
	Choice	Good	Medium	Common	Inferior	Choice	Good	Medium	Common	Inferior	
No. animals	31	12	10	10	10	8	10	11	9	9	
Carcass characteristics											
Score	75.0	75.2	75.0	71.1	64.2	80.6	80.7	80.4	72.7	68.7	4.5**
Dressing percent	55.9	56.6	56.0	56.0	53.4	57.6	58.6	57.4	55.2	55.8	1.4**
Percent shrink	3.4	3.0	3.7	2.8	3.7	2.8	3.4	3.2	3.2	2.7	—
Percent round	26.4	25.8	26.5	26.1	26.3	24.8	25.3	25.1	25.6	26.1	−0.8**
Percent loin	9.7	9.7	9.6	9.8	9.3	9.9	10.0	10.2	9.1	9.2	—
Percent rib	22.4	22.2	22.2	22.0	21.9	23.0	23.1	23.3	23.0	22.1	—
Percent chuck	35.0	35.3	35.1	35.4	35.7	34.9	34.4	34.2	35.0	35.5	−0.5*
Percent plate	6.7	7.0	6.6	6.6	6.7	7.4	7.1	7.2	7.3	7.1	0.5**
Percent bone	15.6	15.8	16.9	16.8	18.1	14.2	13.8	14.0	16.3	17.8	−1.4*
Percent muscle	58.3	58.0	56.9	54.4	62.8	52.8	54.4	54.4	59.4	58.2	−3.8**
Percent fat	25.6	25.5	25.5	23.6	18.5	31.4	31.0	31.2	26.7	23.8	5.1**
Economic factors											
Feeder price	18.22	17.87	16.73	13.16	11.18	18.22	17.87	16.73	13.16	11.18	—
Live slaughter price	20.17	19.40	16.55	16.25	14.40	21.31	19.60	19.86	17.64	15.97	—
Carcass price	30.39	31.50	31.75	28.95	26.60	31.69	33.25	33.27	31.33	29.72	2.01*
Carcass weight x price	154.05	169.96	154.23	147.59	122.22	193.85	190.83	180.99	174.34	164.74	30.77**
Live slaughter weight x price	181.44	184.14	142.66	149.04	122.97	218.02	190.80	186.25	176.28	159.96	29.67**
Weight cuts x price	166.80	184.68	166.19	164.91	134.99	206.87	202.36	192.03	179.23	165.90	25.24**
Gain data											
Average daily gain	1.6	1.6	1.7	2.0	1.8	1.8	1.6	1.7	1.5	1.8	—
Lbs. hay/lb. gain	7.1	7.2	7.3	6.7	6.3	6.1	6.9	6.4	8.4	5.8	—
Lbs. grain/lb. gain	6.4	6.8	6.5	6.5	6.1	6.1	6.9	6.3	7.9	6.0	—

[a] Nonsignificant differences omitted.
* Significant at 0.05 level.
** Significant at 0.01 level.

relation between slaughter total score and slaughter price is 0.88. Partial correlation analysis indicates that total score is sufficient to describe the merit of an animal.

Means of the production factors classified by feeder grade and feeding period (Period I, 90 days; Period II, 150 days) are presented in table 1. Period mean differences are shown in the last column. A significant grade $\times$ period interaction was observed for average daily gain. Choice feeders fed 150 days had a higher rate of gain than those fed 90 days, while Common grade feeders fed 90 days had a higher rate of gain than those fed 150 days. There were no grade or period differences or interactions with respect to economy of gain.

Carcass score, dressing percent, percent plate and percent fat increased, whereas, percent muscle, percent round, percent chuck and percent bone decreased with longer feeding. A grade $\times$ period interaction was observed for percent shrink and percent rib. There were no period or grade differences for percent loin. The period difference in carcass price is due to the larger number of higher-grading carcasses after the longer feeding period. The remaining period differences are the result of increased grade and weight for the longer feeding period. The observed differences in feeder price associated with feeder grade are largely automatic. There was a grade $\times$ period interaction for slaughter price. This appears to be due to the very small period difference for steers grading Good.

Differences among carcass and economic factors due to feeder grade were estimated. Feeder grade did not separate any of the carcass traits into all possible classes and is not an accurate indicator of carcass traits. A large number of significant differences for slaughter weight $\times$ price resulted from the fairly high relation between feeder grade and slaughter grade. The remaining differences indicate that feeder grade is not highly indicative of subsequent economic value.

Means of the production factors classified by slaughter grade and feeding period are presented in table 2. A grade $\times$ period interaction was observed for average daily gain. There were no differences in economy of gain. There was a decrease in percent round and muscle and an increase in percent plate with increased length of feeding period. There was a grade $\times$ period interaction for carcass score, percent rib and percent fat. Choice and Good slaughter steers yielded higher scoring carcasses at the end of 150 days, while Commercial and Utility slaughter steers yielded lower scoring carcasses after 150 days on feed. This interaction probably indicates an inconsistency on the part of the graders. The same pattern of differences was observed for percent rib and fat. There is no immediately apparent explanation of the period difference in feeder price. The remaining period differences are the result of the larger gains of animals fed longer.

Differences among carcass and economic factors due to slaughter grade were estimated. Slaughter grades did not produce all possible differences for any of the carcass traits. All possible differences for slaughter price

TABLE 2. MEANS OF PRODUCTION FACTORS CLASSIFIED BY SLAUGHTER GRADE AND FEEDING PERIOD

Item	Period I Slaughter grade					Period II Slaughter grade					Period mean diff.[b]
	Choice	Good	Commercial	Utility	Cutter	Choice	Good	Commercial	Utility	Cutter[a]	
No. animals	9	20	10	7	5	23	13	8	3	0	
Score	76.0	74.4	71.7	68.1	63.0	81.4	76.6	68.2	65.0	—	—
Dressing percent	57.9	55.3	56.2	54.7	53.2	58.1	56.6	54.9	55.8	—	—
Percent shrink	3.3	3.3	3.0	3.1	4.1	3.3	3.0	2.9	2.1	—	—
Percent round	25.7	26.4	26.0	26.2	26.7	24.9	25.8	25.8	26.7	—	—0.5*
Percent loin	9.8	9.6	9.7	9.8	9.1	10.0	9.8	8.9	9.0	—	—
Percent rib	22.7	22.0	22.0	22.0	22.0	23.4	22.7	22.2	21.7	—	—
Percent chuck	34.6	35.5	35.5	35.2	35.7	34.3	34.7	35.8	35.9	—	—
Percent plate	7.2	6.6	6.7	6.7	6.6	7.4	7.0	7.3	6.8	—	0.4**
Percent bone	14.2	16.9	16.1	18.0	19.2	13.9	15.1	17.1	20.0	—	—
Percent muscle	58.4	57.8	58.8	60.9	63.0	52.3	56.2	59.4	58.6	—	—2.4**
Percent fat	26.4	24.8	24.8	20.5	17.6	32.1	28.4	23.5	21.3	—	—
Feeder price	18.00	17.33	13.80	12.42	10.80	17.33	15.29	12.34	11.00	—	1.43**
Slaughter price	20.61	18.41	16.30	15.00	12.90	20.60	18.40	16.56	14.00	—	—
Carcass price	34.94	28.65	30.75	28.36	26.20	34.59	31.15	27.50	27.00	—	—
Carcass weight x price	194.41	142.10	153.52	132.13	122.87	205.88	164.00	143.20	162.99	—	17.11**
Slaughter weight x price	198.27	164.55	145.48	127.51	113.34	208.08	170.83	158.30	151.29	—	10.52**
Weight cuts x price	207.55	156.24	167.78	145.17	138.29	218.55	172.42	143.66	159.91	—	—
Average daily gain	1.7	1.6	2.1	1.5	1.8	1.8	1.5	1.5	1.7	—	
Lbs. hay/lb. gain	7.1	7.0	5.9	8.4	6.4	6.3	7.3	7.5	5.8	—	
Lb. grain/lb. gain	6.2	6.6	5.3	8.2	6.1	5.9	7.3	7.6	6.4	—	

[a] There were no Cutters at end of Period II.
[b] Nonsignificant differences omitted.
* Significant at 0.05 level.
** Significant at 0.01 level.

were significant, as expected since slaughter price is determined largely on the basis of grade. Slaughter grade did not result in all possible significant differences for carcass price. Since carcass price is largely determined by grade, this supports the suggestion that slaughter grade is not a highly accurate indicator of carcass grade.

TABLE 3. THE EFFECT OF CARCASS GRADE AND FEEDING PERIOD ON FEEDER AND SLAUGHTER TOTAL SCORES AND MEASUREMENTS

	Period I				Period II				
	Carcass grade				Carcass grade				Period
Item	Choice[a]	Good	Commercial	Utility	Choice	Good	Commercial	Utility	mean diff.[b]
No. animals	..	26	19	6	9	26	7	5	...
Score									
Feeder	..	76.0	67.9	53.3	80.2	73.0	58.3	54.6	—4.0*
Slaughter	..	76.3	70.6	57.7	88.4	82.1	70.4	63.9	4.4**
Feeder measures									
Weight	..	744	758	700	787	696	779	810	...
Height at withers	..	43.2	44.3	46.0	43.4	42.6	45.3	47.3	...
Height at hooks	..	46.0	47.4	48.8	46.1	45.3	48.4	49.9	...
Chest width	..	14.2	13.9	13.0	14.3	13.4	14.0	13.2	...
Hooks width	..	16.4	16.2	15.2	15.7	15.9	16.4	16.4	...
Heart girth	..	63.4	65.0	61.7	65.0	62.0	65.1	66.2	...
Round	..	39.1	40.1	36.3	39.9	39.7	37.5	37.3	...
Body length	..	52.3	52.8	53.6	55.1	52.6	54.6	51.6	...
Ht. withers x 100 / Heart girth	..	68.2	68.3	74.7	66.8	68.4	69.5	71.5	...
Length x 100 / Heart girth	..	83.5	81.4	86.9	84.9	83.9	84.0	78.0	...
Chest width x 100 / Heart girth	..	22.4	21.4	21.0	22.0	21.5	21.5	19.9	—.67*
Slaughter measures									
Weight	..	897	914	850	1067	944	1025	1031	...
Height at withers	..	45.9	47.8	49.6	47.2	47.0	49.9	51.3	1.4**
Height at hooks	..	48.8	50.5	52.8	49.8	49.7	53.3	54.3	1.5**
Chest width	..	15.8	15.7	14.7	17.1	16.1	16.8	15.8	0.6*
Hooks width	..	17.4	17.6	16.7	18.9	17.9	18.7	18.2	0.8**
Heart girth	..	70.3	71.2	70.0	75.0	71.3	73.8	73.8	1.8**
Round	..	42.1	42.3	41.6	42.3	41.1	41.1	40.8	1.0*
Body length	..	55.7	55.2	55.1	57.5	54.7	55.4	56.0	...
Ht. withers x 100 / Heart girth	..	65.4	67.2	70.9	62.9	56.6	56.5	56.6	...
Length x 100 / Heart girth	..	79.3	77.7	78.8	76.5	76.8	75.2	76.0	2.5**
Chest width x 100 / Heart girth	..	22.5	22.1	21.0	22.7	22.6	22.8	21.5	...

[a] There were no Choice carcasses at the end of 90 days.
[b] Nonsignificant differences omitted.
* Significant at 0.05 level.
** Significant at 0.01 level.

Means of feeder and slaughter total score and measures classified by carcass grade and feeding period are shown in table 3. Period mean differences are shown in the last column. The only significant period difference among feeder measures was for the ratio of chest width $\times$ 100/ heart girth. Period mean differences among feeder measurements would not be expected. Among the slaughter measures a significant grade $\times$

period interaction was observed for body weight. This appears to be due to the lighter weight of the utility steers at the end of 90 days (Period I). There were no other interactions. There was no change in body length during the last 60 days, but the ratio of length × 100/heart girth changed as a result of the change in heart girth. The remaining two ratios did not change during the last 60 days.

Estimated differences among feeder and slaughter total scores and measures associated with carcass grade were computed. The data indicate that feeder and slaughter grades are fairly accurate indicators of carcass grade. There were no significant grade × period interactions among the feeder measures. In no instance were all six possible differences observed. The magnitude of most of the differences suggest that definitive measures might exist. Among the slaughter measures, the ratio of height at withers/heart girth separates all of the carcass grades. Five of the six possible differences were observed for height at withers and height at hooks. This indicates that, within a population, a body measurement or combination of measurements might be found that can be used to predict carcass grade with reasonable accuracy. This would be of considerable practical value.

These results are in general agreement with those of previous investigators (Bogart *et al.*, 1956; Durham and Knox, 1953; Hankins and Burke, 1938; Hultz, 1927; Knapp *et al.*, 1941; Knapp and Clark, 1951; Knox, 1957; McDonald and Bogart, 1955; Patterson *et al.*, 1949; Stanley and McCall, 1945; Yao *et al.*, 1953).

Relations Between Body Measurements and Production Factors. Most of the correlations between the feeder measures and gain data are insignificant, and none are sufficiently high to be of any practical value. These results are similar to those of Lush (1928, 1932). The data indicate that none of the body measurements or proportions studies is of practical value in determining an animal's subsequent ability to gain rapidly and economically.

Correlations between feeder measures and carcass data indicate that taller feeder steers tend to produce lower grading carcasses. There is a low but real positive relation between feeder chest width and carcass score (0.22) and between round and carcass score (0.26). The relations involving dressing percent, percent shrink and percent of the various wholesale cuts are either low or insignificant. The direction of the relations is, in general, as might be expected. A negative correlation between round measure and percent round is an exception, and indicates that the physical measurement of the round is inappropriate in that it does not reflect the relative size of the round. Relations involving the composition of the 9–10–11 rib are either insignificant or too low to be of practical value.

Correlations between feeder measures and the economic data suggest that taller animals sell for less as feeders and at slaughter, but there is no discrimination with respect to carcass price or value. This is not expected

in view of the negative correlation between the height measures and carcass score. Feeder steers that are wider at the chest are favored as feeders and at slaughter, and produce favored carcasses. Width of hooks is not related to these values. This is probably the result of chest width indicating muscular and skeletal development while width of hooks indicates only skeletal structure. The remaining relations are low or insignificant. It appears that from the viewpoint of feeder, slaughter and carcass price per pound, and total value, the desired feeder measures are low at withers and hooks, wide of chest, and large of round. These are essentially the proportions described by Lush (1928, 1932). In general, the observed correlations between the feeder measurements and the production factors studied are insignificant or too low to be of practical value.

The low positive correlation between rate of gain and size, 0.33, is as expected. None of the slaughter measures are related to economy of gain. These results are similar to the findings of Yao *et al.* (1953) with Shorthorn steers.

Correlations between slaughter measures and carcass weight $\times$ price, live slaughter weight $\times$ price and the sum of the weight of the cuts $\times$ price are quite high and are due to their relation to weight. Insignificant correlations between height at withers and height at hooks with these three measures of carcass value indicate that the increased weight of taller animals is offset by the decreased price per pound. It appears that the desired proportions at slaughter are low at withers and hooks relative to total size (measured by heart girth), and wide at chest. Body length apparently is of no importance. These proportions are essentially the same as those found by Lush (1928), Black *et al.* (1938), Yao *et al.* (1953) and Kidwell (1955).

Correlations between slaughter measures and carcass traits suggest that desirable carcass score is indicated by the same proportions as high economic value. Dressing percent is positively associated with measures indicative of finish. None of the measures are highly associated with percent shrink. Few of the correlations between measures and percent of the wholesale cuts are significant. White and Green (1952) and Green (1954) found high relations between body measurements and weight of certain wholesale cuts. The ratio of height at withers to heart girth is most highly associated with the carcass traits.

Multiple regression equations of average daily gain, and of economy of gain, on various combinations of the feeder measures and ratios were computed. Feeder measures and ratios account for only 16 to 20% of the variation in these traits. Clearly, none of the feeder measurements or combinations of them are useful indicators of a steer's ability to gain rapidly or economically.

Multiple regression equations of the various carcass traits on combinations of three, four and five of the feeder measurements and ratios were

computed. In no case did the multiple regression account for more than 50% of the variation in the trait. The feeder measures used in this study are not useful indicators of the carcass traits considered.

The regression of feeder price, Y_1, on feeder height at withers, X_1; height at hooks, X_2; chest width, X_3; height at withers $\times$ 100/heart girth, X_4; and chest width $\times$ 100/heart girth, X_5; was computed.

$$Y_1=58.0-1.71X_1-0.70X_2+6.23X_3+0.79X_4-3.49X_5 \quad R^2=0.66$$

The partial regression coefficients were all significant, and the standard partial regression coefficients were of similar magnitude. The five variables account for 66% of the variation in feeder price.

The multiple regression of live slaughter price, Y_2, on the same five feeder measures was computed. Only one of the partial regression coefficients was significant.

The regression of live slaughter price, Y_2, on slaughter height at hooks, X_6, height at withers $\times$ 100/heart girth, X_7, and chest width X 100/heart girth, X_8, was computed.

$$Y_2=45.9-0.20X_6-0.43X_7+0.49X_8 \quad R^2=0.57$$

These measurements accounted for 57% of the variation in slaughter price.

The regression of carcass score, Y_3, on the same measures was computed.

$$Y_3=143.2-0.43X_6-1.08X_7+1.11X_8 \quad R^2=0.46$$

They accounted for only 46% of the variation in carcass score. These variables accounted for only 29% of the variation in carcass price.

Accurate, quantitative indicators of an animal's subsequent rate and economy of gain and slaughter and carcass qualities have long been sought by beef cattle breeders. These analyses indicate that the feeder measures studied are not useful in predicting the production factors. The slaughter measures are more closely associated with the economic and carcass traits. The potential utility of such relations, and the need for additional quantitative data relating to growth and development warrants additional investigations.

Relations Among Production Factors. Correlations among carcass traits indicate that percent shrink is not associated with carcass grade or composition. Kidwell and McCormick (1956) found percent shrink to be unrelated to grade. Significant correlations would be expected if fat cover affects shrink.

The correlation of 0.89 between score and percent fat in the 9–10–11 rib indicates that fatness is by far the most important single factor in determining grade. Seventy-nine percent of the variation in carcass score is accounted for by variation in fat. Partial regression analysis indicates that, except for percent rib, the correlations of carcass score with dressing percent and percent of the wholesale cuts are due to the influence of fat. It follows that higher-grading carcasses yield less bone, muscle, chuck and round, but more loin, rib and plate. These relations suggest a need for further study of carcass grades, particularly with respect to grade criteria

and interpretation. Relations involving dressing percent are similar to those for carcass score.

It should be noted that for each correlation much of the observed relation among the five wholesale cuts is spurious in the sense described by Pearson (Snedecor, 1956). The percent rib appears to be independent of percent loin and plate. It appears that the proportion of round can be increased at the expense of loin and rib, and is associated with an increase in chuck. An increase of loin results in a marked decrease in chuck but an increase in plate. A decrease in chuck will increase rib and decrease plate.

An increase in round is associated with an increase in bone and muscle and a decrease in fat. An increase in loin is associated with a decrease in bone and an increase in muscle and fat. A higher proportion of rib is associated with a decrease in bone and muscle, and an increase in fat. Relations involving bone, muscle and fat, and chuck and plate indicate an undesirable antagonism.

The data indicate no association between percent bone and muscle. An increase in percent fat decreases the percent of both bone and muscle. Partial regression analysis indicates these relations would be little changed in a weight constant population. The use of these relations in a selection program requires a knowledge of genetic and environmental correlations among the traits. These estimates must await further experiments designed to provide such information.

Simple correlations between carcass and economic data indicate that carcass score and dressing percent are closely associated with all of the economic measures considered. Percent round is also closely associated, but in a negative manner, to the economic traits. It appears that the almost universal recommendations to select animals with a relatively large round is unwarranted. The association of percent loin, rib, and chuck with the economic measures is positive and real, but low. The positive association of percent plate with the economic measures is contrary to expectation and is probably due to the relatively small amount of plate in the carcass and its relations to the proportions of the other wholesale cuts. The percent bone is negatively related to the economic factors. The relation involving percent muscle and fat indicates that fatter carcasses are valued more highly. There is no association between rate or economy of gain and any of the carcass traits studied.

There is little or no association between rate or economy of gain and the economic measures. The association observed between rate and economy of gain, i.e., the more rapidly gaining animals requiring less feed per pound of gain, is in agreement with the results of similar studies.

Zero order correlations among the various economic measures indicate that feeder price is not highly indicative of carcass price or value. The correlation between slaughter price and carcass price is 0.50. Relations among the various economic measures are quite erratic.

The influence of carcass grade on the carcass, economic and gain data was studied. The means are presented in table 4. Significance of differences among the means was determined by the use of Tukey's D which is given in the last column of the table. The results are as expected on the basis of the correlation data. They are also in agreement with the findings of Kidwell and McCormick (1956).

The Relation of Carcass Grade and Fatness to Consumer Preference. The eighth rib was removed from the right half of each carcass of the

TABLE 4. MEANS OF PRODUCTION FACTORS CLASSIFIED BY CARCASS GRADE

Item	Carcass grade				Min. sig. diff. between means[a, b]
	Choice	Good	Commercial	Utility	
No. animals	9	52	26	11	—
Carcass score	86.3	77.7	69.2	61.4	2.7
Dressing percent	59.8	56.5	55.8	53.3	1.7
Percent shrink	3.4	3.2	3.1	3.0	—
Percent round	24.4	25.8	25.8	27.0	1.3
Percent loin	10.2	9.9	9.5	8.7	1.0
Percent rib	24.3	22.6	22.2	21.4	0.1
Percent chuck	33.6	34.8	35.5	36.2	0.8
Percent plate	7.5	6.9	7.0	6.6	0.5
Percent bone	12.8	15.4	16.3	20.2	2.0
Percent muscle	51.5	55.7	60.1	62.5	2.7
Percent fat	35.6	28.2	22.9	17.0	2.4
Feeder price	17.53	16.7	14.2	11.2	1.9
Slaughter price	20.58	18.96	17.11	14.34	1.65
Carcass price	36.78	32.38	27.85	26.09	2.86
Carcass wt. x price	233.87	169.48	146.98	219.88	24.97
Slaughter wt. x price	214.66	175.36	161.25	133.94	24.93
Wt. cuts x price	252.35	180.79	159.55	132.26	25.08
Average daily gain	1.82	1.67	1.71	1.74	—
Pounds hay/pound gain	6.24	6.88	7.17	6.45	—
Pounds grain/pound gain	5.68	6.53	6.88	6.55	—

[a] Computed as Tukey's D (Snedecor, 1956, pp. 251–253).
[b] Nonsignificant differences omitted.

second group (1955–56) of steers for these studies. Each steak was wrapped, identified and held in the meat tray of an ordinary household refrigerator until cooked. The steers were killed in two groups 60 days apart. Steaks were cut ¾ in. thick and cooked in groups of four to six. Only one group was cooked on any one day, and frequently several days elapsed between groups. The steaks were broiled in a preheated electric over to an internal temperature of 60° C. The top of the meat was 3 inches below the heat source. This required broiling approximately 20 minutes on one side and 10 minutes on the other.

The taste panel consisted of a group of seven staff and faculty members —four women and three men. Each panel member received a small sample

from the same area of each steak. Five criteria of consumer preference were scored. These were tenderness, flavor of muscle, flavor of cover fat, quantity of juice and quality of juice. The judges used a score card of adjectives weighted from one to seven in which 7 is excellent, 6 very good, 5 good, 4 medium, 3 poor, 2 very poor and 1 unacceptable. The judges had not had previous taste panel experience and worked independently. The composition of the panel was uniform throughout the test.

The carcass grades and number of steers in each grade were Top Good, 4; Average Good, 10; Low Good, 11; Top Commercial, 6; Average Commercial, 6; Low Commercial, 4; Top Utility, 6; Average Utility, 2. It would have been desirable to have the Choice grade represented, but there were none in this group.

Analysis of variance utilizing the approximate method of unweighted means (Snedecor, 1956) for a 7 x 8 table with disproportionate subclass numbers was employed to estimate the influence of grades, judges and grade $\times$ judge interaction on scores for each of the five consumer preference measures. A significant grade $\times$ judge interaction was observed for quantity of juice. There were no other interactions. Significant differences among judges were found for each of the remaining measures. In each instance, this was found to be due to the extremely low scores of a single judge. There were no differences among the remaining six judges. There were no differences among the eight grades. It follows that either there were no differences among the grades with respect to the preference criteria or the judges were not able to discern them. In the absence of comparative objective measures, e.g., shear tests, etc., it is not possible to choose between the two alternatives. It is possible that other factors such as aging, method of cooking, amount of cooking, seasoning, etc., are more important in determining sensory preferences than the factors considered in this study.

The sequential sampling procedure may have had an effect on the scores. It is possible that, had all the samples been available at one time, the judges might have been able to rank them and thus be more discerning.

These steers were all young and had been gaining at a fairly rapid rate prior to slaughter. It is possible that there were no real differences with respect to the sensory preferences studied. All muscle samples were from the longissimus dorsi (ribeye) muscle.

Cover *et al.* (1956) cited numerous authors who had expressed the belief that increased fatness resulted in increased tenderness and juiciness. It has also been suggested that increased tenderness and juiciness is associated with more rapid gaining animals. Correlation analysis was employed to obtain information on this point and estimate the relations among the consumer preference measures. Quantity of juice was not considered because of the grade $\times$ judge interaction.

Tenderness score is not associated with slaughter score, carcass score, percent fat in the 9–10–11 rib, or any of the other preference measures.

Flavor of the muscle is not associated with either slaughter or carcass score. There is a low correlation between flavor of muscle and percent fat, and a higher one between flavor of muscle and average daily gain. A high correlation between flavor of muscle and quality of juice, 0.79, and a much lower one between flavor of fat and quality of juice, 0.38, suggest that quality of juice is influenced to a much greater extent by muscle constituents. The evidence that flavor of fat is associated with the amount of fat is not conclusive.

Summary and Conclusions

An experiment involving 98 yearling steers was conducted over a two-year period to study the relation of selected production factors to conformation scores and body measurements, associations among the production factors and the relation of carcass grade and fatness to consumer preference.

There is little, if any, relation between feeder grade and subsequent rate or economy of gain. It is positively associated with carcass grade, dressing percent and percent fat in the 9–10–11 rib. Each grade is negatively associated with percent bone and muscle in the 9–10–11 rib and is only slightly or not at all related to the percent of the various wholesale cuts. There is a high relation between feeder grade and feeder price, a lesser association between feeder grade and slaughter price and a small relation between feeder grade and carcass price.

There appears to be no relation between slaughter score and rate or economy of gain, but there is a fairly high relation between slaughter grade and carcass score, dressing percent, and percent bone, muscle, and fat in the 9–10–11 rib. A low but significant relation exists between slaughter grade and percent of the wholesale cuts. There is a high relation between slaughter score and carcass price.

Feeder measures bear little relation to rate and economy of gain, economic, or carcass traits.

Slaughter measures are not related to rate or economy of gain, but height at withers, height at hooks, chest width and the ratio height at withers/heart girth are associated with economic factors. Desirable slaughter proportions are low at withers and hooks and wide of chest relative to heart girth. Relations between slaughter measures and carcass traits are generally low; however, the ratio height at withers/heart girth did separate the carcass grades.

Carcass grade is largely a function of percent of fat in the carcass. Higher grading carcasses yield more fat, less bone and muscle, and a higher percent of loin, rib and plate and a lower percent of round and chuck. Carcass value is positively associated with carcass grade, dressing percent, percent loin, rib, plate and fat and is negatively related to percent bone, muscle, round and chuck. There appears to be no association between carcass value and feeder price, rate or economy of gain.

No association was observed between tenderness score and fatness, average daily gain or any of the other preference measures. Flavor of muscle is associated with percent fat, average daily gain and quality of juice. Quality of juice is more dependent upon muscle constituents than on fatness.

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SYNCHRONIZATION OF ESTRUS AND OVULATION IN SWINE [1]

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A DEPENDABLE method of controlling estrus and ovulation in swine would permit many alterations in present breeding practices, such as more uniform farrowing dates and breeding of large groups of gilts. Tanabe *et al.* (1949) have shown that injected gonadotrophins induce ovulation in gilts and sows during both the luteal and follicular phases of the estrous cycle. However, induced estrus was not observed in any gilts or sows treated in the luteal phase. Spalding *et al.* (1955) induced ovulation in gilts during the various phases of the estrous cycle by a single injection of gonadotrophin but induced estrus did not occur in any treated gilts. Cytological studies indicated the ova from induced ovulations reached the same stage in the maturation process as those from normal ovulations. It was also found that some of the ova from induced ovulations were capable of fertilization when gilts were injected during the luteal phase and force bred.

According to Ulberg *et al.* (1951) and Baker *et al.* (1954) daily injections of adequate doses of progesterone consistently inhibited heat and ovulation in gilts. However, the fertility of ova ovulated at the estrous period following the progesterone injections was low and the incidence of cystic follicles was increased in the progesterone treated groups.

The present investigation was undertaken to study the influence of different hormonal treatments on the control of estrus and ovulation in swine. Primary emphasis was placed on the synchronization of estrus and ovulation and on the fertility of ova ovulated at the controlled estrous period.

Experimental Procedure

Observations were made on 58 purebred and crossbred gilts of the Duroc, Poland China, Yorkshire, Landrace and Tamworth breeds. The gilts were obtained from the Iowa State College swine breeding herd and were self-fed or full-hand-fed a complete mixed ration throughout the investigation.

The hormonal treatment employed to recycle gilts by inducing ovulation

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and estrus consisted of a follicle stimulating hormone preparation (Armour's Pituitary Gonadotrophin, predominantly FSH) and estradiol benzoate. Forty Armour Units (A.U.) of FSH were administered as a single intramuscular injection at various stages of the estrous cycle and the estrogen was given intramuscularly 24 hours later at levels ranging from 5 to 80 mg. All gilts had previously been checked daily with a vasectomized boar to determine the occurrence of estrus. Daily checks were made with mature boars from the time of injection until the gilts were slaughtered. Gilts failing to show induced estrus were slaughtered at various time intervals after the injection to make observations on ovarian morphology, whereas those bred were slaughtered 1 to 2 days after the end of estrus.

Sixteen gilts were given a single injection of FSH on a specific day of the estrous cycle to study the effect exerted by corpora lutea formed from induced ovulations on the time interval to the first post-treatment estrus. The dose levels employed were 20, 30 and 40 A.U. per gilt with each level administered at each of the following stages of the estrous cycle: early, middle and late luteal phases and early follicular phase. Daily estrous checks were made following the administration of FSH and the gilts were bred at the first estrus after treatment. The gilts were slaughtered following estrus and the reproductive tracts flushed with saline to recover the ova. The fertilization rate was determined by the number of recovered ova showing cleavage stages of two or more blastomeres. The uteri and ovaries were examined for the presence of gross anatomical abnormalities.

Results

As shown in table 1, one gilt (no. 4) out of a group of eight injected with FSH and estradiol benzoate during the luteal phase of the estrous cycle showed induced estrus. Estrus was manifested in this gilt 2.5 days after the initial injection of 40 A.U. of FSH which was followed by an injection of 30 mg. of estradiol benzoate. Cellular debris, principally leucocytes, in the uterine horns and Fallopian tubes prevented recovery of any of the 10 ova ovulated.

Although boar acceptance was not induced in seven gilts, a behavior response to FSH and estrogen was evident in these gilts in the form of restlessness and a tendency to mount other treated gilts. This response corresponded closely to the actions of untreated gilts immediately prior to the estrous period.

As shown in table 1, three out of four gilts (nos. 10, 11 and 12) injected during the early follicular phase exhibited boar acceptance. Estrus occurred 2.5 days after the FSH injection and the gilts were bred daily during estrus. Twenty-eight ova recovered from two gilts (nos. 10 and 11) showed an average fertilization rate of 82%. An average of five induced ovulations was evident upon examination of the ovaries in four gilts that ovulated of the eight gilts injected during the luteal phase (table 1). An average

of 19 ovulation sites were found in three gilts ovulated during the follicular phase (nos. 9, 10 and 11). The ovulation sites observed in gilts injected in the follicular phase may have been the result of both normal and induced ovulations. However, the appearance of the corpora lutea and the time required for the fertilized egg to show the first cleavage stage indicate ovulations had occurred at least two days previous to the time of slaughter, or by the 18th day of cycle, in two of these gilts (nos. 10 and 11). The FSH had no apparent effect on follicular development in two gilts (nos. 8 and 12). The ovaries of the latter gilt (no. 12) contained one mature follicle but no corpora lutea were present when the gilt was slaughtered. In three gilts (nos. 2, 3 and 7) induced ovulation sites were

TABLE 1. RESPONSE OF GILTS TO 40 ARMOUR UNITS OF FSH AND VARIOUS LEVELS OF ESTRADIOL BENZOATE

Gilt no.	Day injected	Slaughter weight	Estradiol benzoate	Time from injection to slaughter	Induced estrus	Induced ovulations	Ova recovered	Cleaved ova recovered	Cystic follicles
		lb.	mg.	days		no.	no.	%	no.
	Luteal phase								
1	7	256	20	4	—	3	3	0	13
2	8	300	30	6	—	a	0	..	0
3	14	294	30	6	—	a	0	..	0
4	8	204	30	5	+	10	0	..	0
5	14	276	30	5	—	2	0	..	0
6	11	202	40	4	—	6	0	..	0
7	9	268	60	6	—	a	0	..	12
8	10	252	80	5	—	0	0	..	0
	Follicular phase								
9	16	294	20	6	—	16	0	..	0
10	15	280	30	5	+	17	6	67	3
11	15	280	30	5	+	24	22	86	0
12	15	248	30	5	+	0	0	..	0

[a] Age of corpora lutea could not be determined by gross appearance.

not evident but the time interval from injection to slaughter was sufficient for advanced development of corpora lutea and, consequently, may have permitted the disappearance of the stigma which was the criterion used in determining induced ovulations. However, it was found in a subsequent phase of the present study that in at least some follicles induced to ovulate by hormonal injections there is a slight eversion of the follicular wall at the site of rupture and the stigma remains evident for a longer period of time than the stigma formed by spontaneous ovulations. These observations indicate induced ovulations may not have occurred in these gilts and the 16 corpora lutea observed in a gilt (no. 3) slaughtered on the 20th day of the cycle, may have been maintained past the expected time for regression.

Observations were made on a group of gilts, not included in table 1, in order to detect any estrus-promoting effect of the exogenous hormones which may be exhibited later than 6 days after treatment. Seven gilts

were injected with 40 A.U. of FSH per gilt during the luteal phase and four of these received an additional injection of 5 to 30 mg. of estradiol benzoate 1 day later. Estrus was not induced in any of these gilts but all animals injected with FSH and estrogen exhibited an extended estrous cycle. One gilt injected on the 11th day of the estrous cycle returned to estrus 22 days after treatment. This post-treatment interval was 13 and

TABLE 2. EFFECTS OF FSH TREATMENT ON THE TIME INTERVAL BETWEEN ESTROUS PERIODS AND THE FERTILIZATION RATE OF OVA OVULATED SPONTANEOUSLY AT THE FIRST POST-TREATMENT ESTRUS

Gilt no.	FSH level	Gilt weight	Day of cycle injected	Time from injection to estrus	Estrous interval	Corpora lutea	Ova recovered	Recovered ova fertilized
	A.U.	lb.		days	days	no.	no.	%
1	30	197	14	7	20	23	8	—[a]
2	40	210	15	11	25	12	12	100
3	20	189	6	15	20	10	2	50
4	30	225	10	18	27	12	10	100
5	30	209	7	19	25	0[b]	—	—
6	40	210	8	19	26	17	16	100
7	40	213	9	19	27	16	10	90
8	20	243	17	21	37	13[c]	—	—
9	30	218	8	21	28	12	13	77
10	40	246	6	21	26	13	11	63
11	40	288	16	23	38	13	13	100
12	40	220	13	28	40	16	15	100
13	30	201	17	31	47	0[d]	—	—
14	20	210	14	33	46	15	12	83
15	20	192	12	34	45	11	9	100
16	40	201	5	41	45	9[e]	—	—

[a] Gilt was not bred.
[b] Eight follicles 8–14 mm. in diameter.
[c] Slaughtered 21 days after breeding, 10 living embryos recovered.
[d] Twelve follicles 8–14 mm. in diameter, no ovulation sites.
[e] Slaughtered 18 days after breeding, six living embryos recovered.

14 days in two gilts injected on the 12th and 14th day, respectively, of the estrous cycle. Four out of the seven gilts in this treatment group did not show estrus during a 25-day, post-treatment period extending from the day of injection to the day slaughtered.

Sixteen gilts were injected with FSH between the 5th and 17th day of the estrous cycle (table 2). Eight gilts (nos. 4 through 11) returned to estrus from 18 to 23 days after the single injection which demonstrates a recycling effect due to treatment in 50% of the gilts. Five of the remaining eight gilts (nos. 12 through 16) showed a time interval between injection and post-treatment estrus of 28 to 41 days. In four of these five gilts (nos. 13 through 16), the interval from the estrous period before treatment

to the spontaneous estrus occurring after the injection was 45 to 47 days. Three gilts (nos. 1, 2 and 3) showed no apparent interruption of the estrous cycle after the FSH injection.

The recycling effect of the hormonal treatment did not appear to be influenced by the different injection levels used or to be definitely related to the time of the cycle injected. The number of ova ovulated spontaneously at the estrous period following injection was apparently not influenced by previous treatment. Fertilization rates determined on six of the eight gilts (nos. 4, 6, 7, 9, 10 and 11) exhibiting estrus 18 to 23 days after the FSH injection show that 65 of 73 recovered ova were in cleavage stages of two or more blastomeres.

Ovarian examinations on the gilts given a single injection of FSH (table 2) showed the absence of cystic follicles when slaughtered following the post-treatment estrus. In all phases of this study, follicles found to exceed 15 mm. in diameter were classified as cysts. No other gross anatomical abnormalities of the reproductive tracts were observed in these gilts.

Table 3 shows the number and classification of corpora lutea observed in gilts injected with FSH alone, or with FSH followed by LH, and slaughtered 5 to 12 days after the initial injection. FSH administration on the 13th to 15th day of the estrous cycle induced ovulations in four out of five gilts (nos. 1, 3, 4 and 5). Corpora lutea formed at the estrous period preceding treatment were present on the ovaries as corpora albicantia. Even though these corpora albicantia showed regression, younger corpora lutea resulting from induced ovulations contained vascularized luteal tissue. These fully-developed corpora, which appeared to be functional, are included in table 3 as normal corpora lutea. In addition to corpora albicantia and normal corpora lutea in the ovaries of injected gilts, a 3rd group of corpora, designated in table 3 as hemorrhagic corpora lutea, was observed. The hemorrhagic corpora lutea showed an ovulation point and resembled normal corpora lutea in external appearance. However, further observations revealed that these structures were filled with clotted blood and only a small amount of luteal tissue was present. As shown in table 3, the time interval between injection and slaughter was extended from 5 days to 8 to 12 days in six gilts given a single injection of FSH (nos. 6 through 12). This extension of the post-treatment period did not result in an alteration of the retarded luteal tissue formation since only one out of the six gilts (no. 11) did not show this condition when slaughtered.

As indicated in table 3, the injection of a luteinizing hormone preparation (Armour's Pituitary Gonadotrophin, predominantly LH) was without a detectable effect on luteal tissue formation. Ovaries from three of the four gilts (nos. 12, 14 and 15) given FSH and LH contained 1 or more hemorrhagic corpora lutea. In addition, the number of cystic follicles was markedly increased in gilts injected with LH.

TABLE 3. NUMBER AND CLASSIFICATION OF CORPORA LUTEA FORMED FOLLOWING INDUCED OVULATION

Gilt no.	Injection weight	Day of cycle injected	Armour		Time from injection to slaughter	Day of cycle slaughtered	Normal corpora lutea [a]	Hemorrhagic corpora lutea [a]	Corpora albicantia	Cystic follicles
			FSH	LH						
	lb.		A.U.	mg.	days		no.	no.	no.	no.
1	216	13	40	0	5	18	4	6	10	0
2	200	15	40	0	5	20	0	0	12	0
3	242	15	40	0	5	20	1	0	12	3
4	210	14	40	0	5	19	5	0	10	0
5	232	14	40	0	5	19	0	4	14	3
6	190	10	40	0	9	19	3	4	13	0
7	227	10	30	0	8	18	3	3	8	0
8	200	10	30	0	8	18	0	3	0	0
9	205	10	30	0	8	18	1	4	0	0
10	232	9	30	0	12	22	4	3	16	0
11	195	9	30	0	12	22	3	0	11	0
12	210	13	40	15	5	18	4	8	7	0
13	243	14	40	15	5	19	6	0	13	6
14	225	10	40	15	9	19	0	11	17	1
15	252	9	40	15	9	18	6	1	14	3

[a] Corpora lutea formed as a result of induced ovulation. Normal corpora showed luteal tissue development whereas hemorrhagic corpora were ovluated follicles filled with clotted blood.

A single intramuscular injection of 0.2, 0.5, 1.0 or 2.0 mg. of estradiol benzoate per 100 lb. of body weight induced boar acceptance in ovariectomized gilts (table 4). The onset of estrus occurred 3 days after the estrogen injection in 15 of the 20 treatments. The duration of estrus was 2 days in the case of nine observations, 1 or 3 days in ten, and 8 days in one gilt on the 2 mg. level. One-tenth milligram or less of estradiol benzoate per 100 lb. of body weight did not induce sexual receptivity in ovariectomized gilts (table 4). A distinct swelling of the vulva was observed following 13 of the 16 treatments at levels below that required to induce boar acceptance.

Progesterone injected as levels of 50, 100 and 200 mg. per 100 lb. body weight exerted an antagonistic effect on induced estrus in ovariectomized

TABLE 4. OBSERVATIONS ON INDUCED ESTRUS IN OVARIECTOMIZED GILTS FOLLOWING A SINGLE INJECTION OF ESTRADIOL BENZOATE AND PROGESTERONE

Estradiol benzoate[a]	Progesterone[a]	No. of gilts observed	Average weight	Number showing induced estrus
mg.	mg.		lb.	
2.0	0	2	155	2
1.0	0	4	182	4
0.5	0	8	204	8
0.2	0	8	225	8
0.1	0	8	250	0
0.05	0	4	249	0
0.025	0	4	235	0
1.0	50	2	282	0
1.0	100	2	297	0
1.0	200	2	285	0

[a] Expressed in mg. per 100 lb. body weight.

gilts when given in combination with a single dose of estradiol benzoate. All gilts injected with the progesterone-estrogen combinations had previously shown induced estrus when injected with estradiol benzoate at the 0.2 mg. level.

Discussion. The results obtained in this investigation as well as those reported by Tanabe *et al.* (1949) and Spalding *et al.* (1955) show that the follicular development produced by exogenous gonadotrophins during the luteal phase of the estrous cycle does not induce estrous behavior. The magnitude of the follicular growth is frequently in excess of that observed in untreated gilts immediately prior to estrus. An explanation of the absence of induced estrus in gilts in the luteal phase may be related to the production level of ovarian hormones by the induced follicles, the ratio existing between the progestogens and estrogens, as well as the threshold of the central nervous system to estrus-inducing substances at this stage of the estrous cycle. High levels of exogenous

estrogen administered during the luteal phase 1 day after the injection of FSH produced a marked physiological response in the female reproductive tract but did not induce the sexual behavior pattern of boar receptivity.

The adverse physiological responses noted in the reproductive tracts, such as a pronounced infiltration of leucocytes which appeared to occlude completely the uterine lumen in some gilts, indicate the futility of injecting high levels of estradiol benzoate to induce estrus during the luteal phase. Induced ovulations occurred in the treated gilts but the intrauterine environment did not appear to be conducive to embryonic development.

These results also indicate that the level of progesterone existing during the luteal phase prevents estrus in gilts administered FSH and estradiol benzoate. This antagonism was clearly evident in ovariectomized gilts injected with progesterone and a level of estradiol benzoate that had been previously demonstrated to induce boar acceptance consistently. A similar suppression of estrus by exogenous progesterone has been demonstrated in intact gilts by Ulberg *et al.* (1951) and Baker *et al.* (1954).

Supplementing the available endogenous estrogen in gilts induced to ovulate with FSH in the presence of waning corpora lutea resulted in the induction of estrus 1.5 days after the estrogen injection. The recovery of fertilized ova from these gilts supports the findings reported by Spalding *et al.* (1955) that viable ova are ovulated from the induced follicles.

Although the estrus suppressing effect exerted by progesterone was found to be a major obstacle in the control of estrus with a combined treatment of FSH and estradiol benzoate, this phenomenon offered a different approach to the problem of synchronizing estrus in gilts. Ulberg *et al.* (1951) and Baker *et al.* (1954) found little variation in the time interval from the termination of daily injections of progesterone to the onset of estrus in treated gilts. However, detrimental effects accompanying the administration of exogenous progesterone were low fertility and an increased incidence of cystic follicles.

In order to control estrus by using the recycling effect attributed to progesterone, a group of gilts at various stages of the estrous cycle was injected with FSH to induce corpora lutea of a given age which would furnish a source of endogenous progesterone for a relatively constant period of time. On this basis, a recycling effect from the treatment is considered to be a result of the induced corpora lutea regressing at approximately the same time. Fifty percent of the gilts subjected to this hormonal treatment returned to estrus 18 to 23 days after the FSH injection. However, five gilts in this group showed a post-treatment estrous cycle of 28 to 41 days.

In a subsequent trial, it was determined that incomplete development in part of the corpora lutea formed following induced ovulations may be the cause of an extended post-treatment estrous cycle. Spalding *et al.* (1955) reported induced ovulations had occurred in gilts slaughtered 53 hours after injection of 35–40 A.U. of FSH.

These results and limited data obtained in the present study indicate the time interval from ovulation to slaughter was approximately 2 days less than the interval from injection to slaughter. Therefore, it is felt the post-injection period of 8 to 12 days allowed sufficient time for normal luteal tissue formation before the gilts were slaughtered. A luteinizing hormone preparation administered 1 day after a FSH injection was without an apparent effect on luteal tissue development in the treated gilts.

Summary

Induced ovulations were observed in gilts injected intramuscularly with Armour's Pituitary Gonadotrophin, FSH. The FSH was administered at levels ranging from 20 to 40 Armour Units per gilt. Five to 80 mg. of estradiol benzoate was injected intramuscularly 1 day after a FSH injection to induce boar acceptance in conjunction with induced ovulations. The exogenous estrogen had little effect in promoting estrus in gilts injected during the luteal phase of the estrous cycle, whereas estrus was induced by treatment during the early follicular phase.

Eight out of 16 gilts given a single injection of FSH at various stages of the estrous cycle showed boar acceptance 18 to 23 days after this hormone was administered. Sixty-five of 73 ova recovered from these gilts showed cleavage stages of two or more blastomeres.

Estrus was induced in ovariectomized gilts administered 0.2 mg. of estradiol benzoate per 100 lb. of body weight. However, estrus was not observed in animals receiving 1 mg. of this estrogen and a single injection of progesterone at the rate of 50, 100 or 200 mg. per 100 lb. body weight.

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HERITABILITY ESTIMATES OF POST-WEANING GROWTH TO LONG YEARLING AGE OF RANGE BEEF HEIFERS RAISED ON GRASS [1]

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KNOWLEDGE of the heritability of long yearling weight in range beef heifers is important, since many range men in California select their replacement heifers at long yearling age. This selection occurs at the end of the good grass season. Some cattlemen winter their weaned heifers on the range without supplement, whereas others supplement their heifers during the period in question to prevent weight losses due to the deficient nutritive value of the range at this time.

Since cattlemen, desirous of following a planned selection program, are usually dependent upon heritabilty estimates made elsewhere, it is of interest to see if the heritability of long yearling weight is the same under both of the management schemes mentioned. This problem is dealt with in the present paper.

Material and Methods

The data analyzed in this study are the weaning weights, long yearling weights, and growths from weaning to long yearling age of 305 heifers. These heifers were in two experimental range beef cattle herds, A and B, of similar breeding and managed alike except that in herd A the cows and heifers were supplemented during the fall and winter (post-weaning) when the range was nutritionally deficient, while the cows and heifers in herd B were not supplemented. The herd B heifers almost invariably lost weight during the period in question. Both herd A and B heifers made good gains during the subsequent periods of good pasture. The history and a more detailed description of the constitution and management of these herds is presented by Rollins and Wagnon (1956).

Prior to analysis, weaning weights were adjusted to a standard age of 240 days and long yearling weights to a standard age of 600 days.

Paternal half sib heritability estimates of various traits were made. These estimates were made on an intra-year basis. Table 1 shows the distribution of sire progenies in herds A and B over the years of the experiment. As can be seen in this table, essentially the same bulls were used in both herds.

[1] In cooperation with the U.S.D.A. under Western Regional Project W-1 on beef cattle breeding research.

Some of the bulls were used more than one year. If all years were pooled, there would be cases where pairs of bulls would be repeated and, hence, it would be difficult to assign the proper degrees of freedom for the sire component of variance. To circumvent this problem, the annual data in each herd were grouped into three sets in such a way that no pair of bulls was repeated from year to year within any set. The grouping for herd A were years (36, 42, 43, 46 and 50), (37, 41, 44, 47 and 51) and (39, 40, 45

TABLE 1. ANNUAL DISTRIBUTION OF SIRE PROGENIES IN HERDS A AND B [a]

Sires	Years														
	36	37	38	39	40	41	42	43	44	45	46	47	49	50	51
1	2/1														
16	2/3														
315									5/1	4/1	1/1	0/7			5/0
466		1/3	8/1												
531	2/2	1/1													
533	3/2	4/0	0/7	1/8	7/1	4/0	3/1								
546	3/1	0/1		2/1											
565		0/1													
583				1/0					9/1	7/6		0/2			
596				1/1											
599				1/5											
604				4/0	0/5	2/2	1/0	2/0							
628					1/0		1/8								
635						1/0	2/1	0/2	0/7	1/0					
647					0/2	2/8	8/0	0/1	0/2	3/0	1/1	2/0			
654						4/1									
680								3/0							
699							5/0			1/0	1/2				
720								0/1	0/1						
794										2/2	1/0				
824												5/0	2/0		
834											0/5				
853												1/0	2/1	2/2	
862													1/2	3/1	3/1
865													2/7	4/0	7/4
989														1/5	1/3
992														2/2	
35															4/2

[a] Frequencies for Herd A are above the diagonal line while those of Herd B are below.

and 49), while for herd B they were years (36, 40, 42, 45 and 50), (39, 43, 46, 47 and 51) and (37, 38, 41, 44 and 49). The paternal half-sib intraclass correlation is

$$\frac{S}{W+S}$$

where S is the sire component of variance and W is the within-sire component of variance. The W estimate was obtained by pooling the within-sire sums of squares for all years. The S estimate was an average of the S estimates from each of the three sets of years. This was a simple arithmetic average since the number of sires and the average number of progeny per sire (n) were about the same for each set.

For each set of years we would have

$$S = \frac{MS\ (sires) - W}{n}$$

where MS (sires) would be the mean square for pooled intra-year sire differences in that set of years and W would be the estimate of intra-year, intra-sire variance based on all years in the experiment.

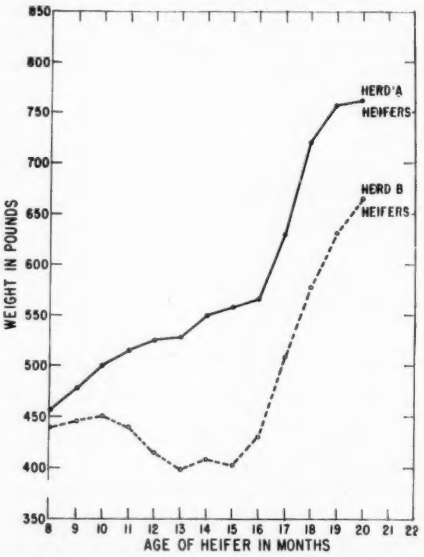

Figure 1. A comparison of weight changes from weaning age to long yearling age of heifers in herds A and B.

In herd B the animals almost invariably lost weight during the fall and winter (figure 1). Out of 140 herd B heifers, 131 lost weight during this period. One gained zero pounds during the period and the remaining eight averaged 0.08 lb. daily gain. The period from weaning to long yearling age was divided into two periods for study. The division was made in the following manner. The first period was from weaning time to the lowest average weight date in herd B. The corresponding time period was used for herd A. This division was possible since all animals in both herds were individually weighed at about monthly intervals on the same day. The second period was from the lowest average weight date in herd B to long yearling age. Use will be made of the following symbols: t=240-day weaning weight, u=total gain from 240-day weaning weight to 600-day long

yearling age, x=average daily gain during period one (fall and winter), y=average daily gain during period two (spring), z=600-day long yearling weight. In calculating x and y for an animal, its actual weaning and long yearling weights were used.

TABLE 2. VARIANCE COMPONENT AND PATERNAL HALF SIB HERITABILITY ESTIMATES

Herd	Estimate	Weaning weight (t)	Total gain, weaning to long yearling age (u)	Average daily gain during period 1 (fall and winter) (x)	Average daily gain during period 2 (spring) (y)	Long yearling weight (z)
A	Sire component of variance S	244	125	—.0022	0.0081	358
A	Within sire component of variance W	2072	1735	0.0306	0.0202	2882
A	Heritability	0.42	0.27	—.30	1.14	0.44
B	Sire component of variance S	319	11	0.0016	0.0005	—142
B	Within sire component of variance W	1908	1286	0.0109	0.0281	3105
B	Heritability	0.57	0.03	0.50	0.07	—.19

Results and Discussion

Estimated variance components and heritabilities for the various traits are presented in table 2.

For the traits t, u, x, y and z, the null hypotheses were tested that the heritability of each of the traits, respectively, were the same in both herds. The null hypothesis was not rejected ($P>.05$) in the cases of traits t, u, and z. Significant differences were found for trait y ($P<.005$) and trait x ($P<.02$). In making the tests of significance, the intra-class correlations from which the heritability estimates were derived were transformed to Fisher's Z scale and then treated as normal variables (Fisher 1946, page 219).

At weaning, the start of the growth period under study, the heritability estimates for herds A and B are quite similar; namely, 0.42 and 0.57. These estimates fall within the range of those reported in the literature. Gregory,

et al. (1950), Koch, *et al.* (1955a, 1955b) and Rollins and Wagnon (1956) report heritability estimates ranging from 0.09 to 0.54 and averaging 0.29.

For long yearling weight, the end of the growth period under study, the heritability estimates for herds A and B were 0.44 and —.19, respectively. While the estimates are not significantly different at the 5% level, it is of interest to note that the herd A estimate is in line with those reported for yearling and long yearling beef steers and heifers raised on grass. Buiatti (1954), Knapp (1950) and Koch, *et al.* (1955a, 1955b) report estimates ranging from 0.43 to 0.76 and averaging 0.61. While the internal evidence of the experiment does not show the herd A and B estimates to be significantly different, the fact that the herd A estimate is in line with those reported in the literature while the herd B estimate is far lower, suggests that the difference is not just due to sampling error.

For gain from weaning to long yearling age, the herd A heritability estimate of 0.27 is in line with those reported in the literature, while the herd B estimate of 0.03 is outside the range. For gains from weaning to yearling or long yearling age of beef cattle on grass, Cartwright (1955), Knapp (1950) and Koch, *et al.* (1955a, 1955b) report heritability estimates averaging .30 and ranging from 0.19 to 0.46.

The breakdown of the growth period from weaning to long yearling age into two periods is of interest since it was only during the fall and winter (period one) that the two herds received differential treatment. During this period, herd B heifers consistently lost weight (figure 1). During the spring (period two) heifers from both herds gained weight. Those of herd A averaged 1.29 lb. per day and those of herd B averaged 1.47 lb. per day.

During period one the herd A heifers averaged 0.43 lb. per day gain while the herd B heifers lost an average of 0.26 lb. per day.

The heritability estimates of gain during the first period (x) are —.30 for herd A and 0.50 for herd B. These estimates differ significantly at the 2% level of probability. The within sire variance in herd A (table 2) is nearly three times as large as that in herd B. A Chi-square test of homogeneity of these two variances rejected the null hypothesis ($P<.001$). In herd A the heifers were not divided into sire groups while being supplemented. The limited supplemental feed of cottonseed cake was put out in bunkers on the range once a day and the heifers were called in; the feeding took about 15 minutes. This feeding method would suggest competition as a source of inflating the variance. Why this inflation is not present in the mean square for sires as well as in the mean square within-sires is not clear to the authors. The negative estimate of the sire component of variance is consequently attributed to sampling error.

During the second period, that of spring growth on good range forage, the heritability estimate of gain for herd A is 1.14 while that for herd B is 0.07. Although these estimates are subject to large sampling errors, a comparison of them is of interest. The difference between these estimates is statistically significant at the 5% level indicating that heritability for

this trait is higher under herd A than under herd B conditions. Since the A and B herds were managed alike during the period in question, the lower heritability estimate for herd B as compared to that of herd A may in part indicate that young growing animals going from a period of weight loss (in this case an average loss of about 10% of body weight for herd B heifers) into a period of weight gain have internal physiological adjustments to make. Under such conditions, the importance of dominance and/or epistatic effects might increase relative to the additively genetic effects in the composition of genetic variability. In a paternal half-sib analysis these effects would inflate the within-sire variance component to a much greater extent than the variance component due to sire differences thus resulting in a lower heritability.

A knowledge of the genetic and environmental correlations between x (gain during the fall and winter) and y (gain during the spring) would be of interest. The data, however, do not seem adequate to make such estimates worthwhile. In the case of herd A, the estimate of the sire component of variance for x is negative and in the case of herd B the estimated sire component of variance for y is so small that its presence in the denominator of the formula for the genetic correlation would make such an estimate of questionable value.

Summary

Estimates of heritability of long yearling weight for range beef heifers raised under two different management schemes have been made. Under one plan (herd A) the heifers were supplemented to promote continuous growth during the fall and winter (post-weaning) when the range was nutritionally deficient, while heifers under the other plan (herd B) were not supplemented and almost invariably lost weight during the period in question. Both herds made good gains during the subsequent spring period of good pasture. Heritability estimates of long yearling weight were 0.44 for herd A and —.19 for herd B. Evidence is presented that the difference between these estimates is not entirely due to sampling error and an explanation is suggested for the existence of a difference in heritability of long yearling weight under the two management conditions.

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SELECTION OF FINE-WOOL RAMS BASED ON RECORD OF PERFORMANCE DATA

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PERFORMANCE testing of rams by the Texas Agricultural Experiment Station is currently in its tenth year. The testing procedures were covered in earlier reports by Dameron *et al.* (1950), Magee (1954), and Shelton *et al.* (1954). From the outset there has been a need to determine the heritability of performance records on rams collected in this manner. This is especially true since the records are collected on a dry lot feeding regimen, whereas the final advantage to be realized from selections would be under range conditions. In early attempts to calculate heritability estimates from this work only half-sib analysis was possible. In general, this method yielded unrealistic values. There also exists a need in this work to develop an index or procedure whereby a single total score may be calculated for final evaluation. The present work was undertaken in an attempt to satisfy these needs.

Experimental

Since the start of this work, 40 different tested Rambouillet rams have been used as sires in the flocks of the Sonora (Texas Agricultural Experiment Station, Substation 14, Sonora) and Barnhart Stations (Texas Range Station, Barnhart). The records of these rams on test in comparison with their offspring were used as the basis for the present study. Since a few individual rams were used in more than one year, the total number of sire years was 45 and the total number of offspring involved was 957. The total number of individual animals involved in some comparisons was less than this number in cases where individual items of data were not complete.

Six characters were considered of paramount importance in selecting fine wool sheep and were included in the present study. These are weaning weight or rate of gain, body conformation or score, face covering, skinfolds, staple length and clean wool production. Other characters such as wool quality and anatomical weakness, which are important, were considered to be well adapted to the use of independent culling levels.

Data on sires included daily gain on test, staple length in inches and clean wool in pounds on 365-day basis, skinfold count, face covering and body conformation scores. Offspring data included adjusted weaning weight,

[1] Acknowledgment is made to Dr. W. T. Hardy and staff of Substation 14, Sonora for assistance in collecting the data used.

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body score and face covering score on lambs at weaning, and skinfold count, staple length and clean wool production as yearlings. Wool production data were adjusted to a 365-day basis. Yearling data from the Sonora Station included only range-raised yearling ewes, whereas data from the Barnhart Station included both ewes and wethers. The lambs from the Barnhart Station were weaned in October at approximately 7-months of age and then placed in the feed lot for a three- to four-month period. Thus, the fleece data and skin fold record were based on a six- to seven-month preweaning period on the range and a three- to four-month period in the feed lot. Face covering on both sires and offspring and body conformation on sires were scored on a 1 to 4 basis with the higher score

TABLE 1. PHENOTYPIC RELATIONSHIPS BETWEEN SIRES AND OFFSPRING

Character	No. of sire offspring pairings	Correlation	Regression	Heritability
Gain and weaning weight	83	0.18	0.11	0.22
Conformation	70	0.04	0.02	0.04
Face covering	83	0.49	0.27	0.54
Skin folds	73	0.35	0.17	0.33
Staple length	73	0.38	0.24	0.48
Clean wool	70	0.32	0.11	0.22

representing a greater abundance of the character being measured. Thus a low score for face covering and a high score for conformation is desirable. Conformation score on lambs at weaning was based on common scoring procedure considering 100 as perfect. Skin folds were counted out of the wool according to a system described by Jones (1946) by weighting each fold for size. The higher value represents more folds.

Heritability. Estimates of heritability were obtained from the regression of mean of the offspring on record of sire on test on a within station-year-sex subgroup basis. These values are shown in table 1. Different units of measure or score were used for conformation of sire and offspring and for rate of gain of sire on test and weaning weight of lambs. In these cases variance was converted to standard units for use in estimation of heritability. It will be noted that the correlation coefficients are consistently higher than the regression coefficients. This can be explained apparently by the fact that the favorable environment of the sires on test as well as selection of the sires used has tended to bias the correlation coefficients upward.

Correlation Studies. Estimates of phenotypic and genotypic correlations between the traits were required for subsequent calculations. Earlier studies indicated that these statistics calculated from ram performance, in which the animals were on a high level of feed intake, may differ markedly from values obtained under range conditions. Since feed lot conditions represent a somewhat artificial environment for fine-wool sheep, it did not appear

wise to base selections entirely on correlation studies made under these conditions. For this reason phenotypic correlations represent the mean of values obtained from five samples of data involving approximately 4000 animals under variable conditions from the flocks at Sonora and Barnhart Stations. The genotypic correlations represent the mean of values obtained from parent offspring comparisons of three samples of data involving up to 3000 parent offspring pairs. The method employed in calculating genetic correlations was that suggested by Lush (1948). The values obtained are shown in table 2. Estimates of genotypic correlations often fluctuated markedly from one sample of data to another; however, when the samples

TABLE 2. PHENOTYPIC CORRELATIONS (ABOVE DIAGONAL) AND GENOTYPIC CORRELATION (BELOW DIAGONAL) FOR CHARACTERS STUDIED

	Rate of gain	Conf. score	Face covering	Skin folds	Staple length	Clean wool
Rate of gain		0.24	—.02	0.12	0.13	0.39
Conformation score	—.10		0.05	0.13	0.23	0.23
Face covering	—.53	0.06		0.14	—.05	0.17
Skin folds	—.06	—.30	0.38		—.24	0.20
Staple length	0.00	0.35	—.14	—.49		0.42
Clean wool	—.24	0.11	0.18	0.17	0.59	

were combined only a few showed consistently high values, and most of these are favorable from the standpoint of overall improvement. The two exceptions to this general rule are the negative correlation between rate of gain and clean wool production and the slight positive relationship between amount of wool on the face and clean wool production.

A detailed study of the various samples of data seems to indicate that where the animals are on a high level of feed intake, as in the case of rams on performance test, there is a positive genetic correlation between body weight gain and clean wool production; but, where feed supply is a limiting factor, as is often the case under range conditions, this relationship is negative. The existence of such a contrast could easily be rationalized based on *a priori* reasoning.

Economic Values. A comparison of the relative economic importance of of each trait is necessary to devise and index best to effect overall improvement. The values used in the present study are shown in table 3. The details of how these were derived are too lengthy to be reported here. Essentially, ten-year average prices of $21.33 per hundred for lamb and $1.24 per pound for clean wool were used. The remaining characters were evaluated for their influence on quantity or quality of these major products or for their importance in respect to the management program. The value for face covering was based on a report by Shelton and Carpenter (1957). The importance of staple length was based on a report by Davis and Gabbard (1953). The value for body conformation was obtained from a

study of relative prices of grades on Fort Worth market, and the factor for skin folds was based largely on unpublished data available from the Texas Agricultural Experiment Station.

Index. An index for application to performance record of rams was calculated combining the six characters included in the study. The detailed calculations are not included in the present report, but in general the procedure followed was that outlined by Hazel (1943). The index obtained was as follows:

$$I=40+58.1 \text{ (daily gain)}-1.9 \text{ (body conformation)}-5.2 \text{ (face covering)} -0.089 \text{ (skinfolds)}+8.8 \text{ (staple length)}+0.61 \text{ (clean wool)}.$$

TABLE 3. RELATIVE ECONOMIC IMPORTANCE OF VARIOUS CHARACTERS

Character	Unit of measure	Estimated actual value	Relative to clean wool	Standard deviation[a]
Weaning weight	1.0 pound	$0.213	1.72	0.06[a]
Weaning score	1.0 score	0.119	0.96	0.51[a]
Clean wool	0.1 pound	0.123	1.00	1.26
Staple length	1.0 inch	0.827	6.67	0.38
Face covering	1.0 score	−.625	−5.04	0.97
Skin fold	1.0 count	−.001	−.09	20.99

[a] Standard deviation of record of rams on test including all Rambouillet rams tested calculated on within year basis. As discussed previously the units of measure are different for parent and offspring in case of the first two characters. Adjustment was made for this disparity in making calculations.

Discussion

During the progress of the present study and other work devoted to the development of a selection program for fine wool sheep under Texas conditions, a number of significant facts were indicated. The most noted of these is the negative value for body conformation in the above index which would indicate that the breeders should exert some pressure against conformation in order not to over-emphasize this character in the breeding program. These rams were scored for conformation by a committee at the end of the feeding period and out of wool. When scored the rams were 12 to 18 months of age and showing relatively mature body form. Those receiving better conformation scores represent those that tend to be thick and more blocky in form. There may also be a tendency for these to represent an earlier maturing type of animal which has put on a larger amount of fat during the test period. As indicated by the heritability estimate this type of conformation score of the sire has relatively little influence on weaning score of their lambs, but it is negatively related to a number of other characters in offspring such as weaning weight ($r=-.074$) and wool production ($r=-.138$ for grease wool and $-.241$ for clean wool). Thus it appears that there is no advantage to be gained from selecting for conformation according to conventional standards for fine wool sheep

under range conditions. In practice, recommendations to producers have been to the effect that they should not strive for perfection in conformation but should endeavor to stay within commercially acceptable types. In effect this would remove conformation from the selection index and leave it as an independent culling level. Other studies at this station (Shelton, 1957) involving weaning lambs have shown that producers are justified in selecting for higher scoring lambs at weaning.

This study indicates that in selecting rams out of performance test, the three factors, rate of gain, face covering and staple length are of paramount importance. Clean wool production and staple length are highly correlated, both phenotypically and genotypically, and thus selection for either should bring about some improvement in both length and quantity of wool. The index obtained in the present study indicates that emphasis should be primarily on staple length. However, in developing an estimate of the economic importance of staple length it was assumed that the value of wool increased in a direct linear manner with increasing staple length and that an unlimited increase in staple length was desirable. Neither of these conditions seem to be entirely true, and in early attempts to utilize the above index it appeared to over-emphasize the value of extremely long staple animals. For this reason the index has been modified in practice to give more nearly equal emphasis to staple length and clean wool production.

Summary

Studies are reported which had as their primary objective the development of a selection index for application to performance records on fine-wool rams. Included are estimates of the relative economic importance, phenotypic and genotypic correlations and heritability of rate of gain, body conformation, face covering, skin folds, staple length and clean wool production. The heritability estimates obtained were weaning weight and rate of gain, 0.22; conformation, 0.04; face covering, 0.54; skin folds, 0.34; staple length, 0.48; and clean wool, 0.22. The index derived indicated that primary emphasis should be placed on rate of gain, face covering and staple length.

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EFFECT OF ADRENALINE ON SERUM PROTEINS AND VITAMIN A METABOLISM IN CATTLE AND SHEEP [1, 2]

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IN vitamin A investigations, a variable amount of excitement is created when cattle and sheep are restrained for the withdrawal of blood and liver samples. With rats, Klopp *et al.* (1951) found that adrenaline injections resulted in an increased serum vitamin A content. Further, adrenalectomized dogs and rats exhibited a marked reduction of serum vitamin A. Results of other investigations (Goodwin *et al.*, 1949) with rabbits and rats revealed no evidence that adrenaline influenced vitamin A metabolism.

Since no report on the effect of adrenaline on vitamin A metabolism in ruminants was available, studies were conducted with cattle and sheep.

Experimental

Bovine. Four sets of identical twin calves, weighing approximately 750 lb., of various breeds (Holstein, Santa Gertrudis and crossbred) were fed carotene-free rations. One co-twin in each set served as a control while the other one was injected intramuscularly with adrenaline, 4 mg. per 100 lb. body weight. Serum proteins from blood withdrawn prior to and 4 hours after treatment were separated in a Spinco Model R electrophoresis apparatus on paper strips in sodium veronal buffer (pH=8.6; μ=.075) for 16 hours. Carotene and vitamin A (Kimble, 1939) were determined on plasma from blood withdrawn prior to and at 1, 2, 4, 6, and 8 hours after treatment. Liver samples were withdrawn (Erwin *et al.*, 1956) prior to and at two days following treatment for carotene and vitamin A determinations by the method of Gallup and Hoefer (1946).

Ovine. In trial I, 10 wethers weighing approximately 70 lb. were divided into two groups and one of the groups intramuscularly injected with 4 mg. adrenaline per 100 lb. body weight. Vitamin A (Kimble, 1939) was determined on plasma from blood withdrawn prior to and at 1, 2, 4, and 8 hours after treatment.

In trial II, eight fat wether lambs weighing approximately 102 lb. were divided at random into two groups of four animals each. One group was subcutaneously injected with 1 mg. adrenaline per 30 lb. body weight, initially and at 1, 2, and 4 hours, while the other group served as control. Blood was withdrawn from the lambs prior to injection and at 1, 4, and 19 hours for vitamin A analyses.

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[2] Arizona Agricultural Experiment Station Technical Paper No. 502.
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Results and Discussion

Several investigations have shown that certain serum proteins bind vitamin A and carotene and thus provide for their transportation in the blood to sites of utilization (Ganguly *et al.*, 1952; Dzialoszynski *et al.*, 1945). Gleye *et al.* (1954) have shown that adrenaline markedly reduces serum albumin in the guinea pig. Possibly, the effect of adrenaline on the alteration of vitamin A in the blood of man and monogastric animals reported by Hillman (1949) and Klopp *et al.* (1951) was predisposed by changes in serum protein fractions.

Adrenaline injections altered neither the ratio of serum proteins in cattle (table 1) nor plasma carotene and vitamin A levels of cattle and

TABLE 1. EFFECT OF ADRENALINE ON SERUM PROTEIN FRACTIONS [a] OF CATTLE

Group and time interval	Albumin, %	Globulins, %		
		Alpha	Beta	Gamma
Injected				
0 hours	57.6 3.5	12.0 2.1	10.9 5.7	19.5 2.8
4 hours	54.9 1.9	12.9 0.7	11.8 1.7	20.3 2.1
Control				
0 hours	51.5 2.4	13.4 2.2	14.0 6.3	20.5 4.1
4 hours	50.1 4.6	12.1 1.6	14.1 6.9	23.7 2.8

[a] Expressed as percent of total serum proteins and standard deviation from the mean, respectively.

sheep (table 2). Further, the hormone did not influence the content of carotene and vitamin A in the bovine livers even though adrenaline markedly altered the physical activity of the calves. These results suggest that factors regulating vitamin A metabolism may be different in the ruminant from those in certain monogastric animals.

All lambs in trial II were slaughtered 24 hours after the initial adrenaline injection. As compared to controls, the carcasses from the adrenaline-injected lambs were dark. These observations indicate that the amount of adrenaline administered to the lambs was greater than the amount normally released in stress predisposed by physical restraint. Therefore, results of investigations of vitamin A and carotene in blood and liver as well as serum proteins of ruminants should not be influenced by the variation in excitability at sampling time.

Summary

Intramuscular injections of adrenaline into cattle and sheep influenced neither serum protein fractions nor the carotene and vitamin A content of blood and liver.

TABLE 2. EFFECT OF ADRENALINE ON CAROTENE AND VITAMIN A CONTENT OF PLASMA AND LIVER OF CATTLE AND SHEEP

Animals and treatment	Carotene and vitamin A content[a] of plasma at—												Carotene and vitamin A in liver[b]			
	0		1 hr.		2 hr.		4 hr.		6 hr.		8–19 hr.		Initial		Final[d]	
Carotene																
Injected calves	2.3	0.6	2.4	0.5	2.6	0.6	3.2	0.6	3.6	0.3	3.5	0.4	1.8	0.5	1.4	0.2
Control calves	2.9	0.9	3.0	0.6	2.2	0.3	3.3	0.8	3.5	0.4	3.4	0.4	1.6	0.3	1.5	0.3
Vitamin A																
Injected calves	20.2	3.5	20.1	7.2	19.8	7.1	13.3	9.0	15.4	4.8	16.7	1.7	2.8	2.0	2.0	1.5
Control calves	25.2	8.9	21.3	7.1	20.9	3.3	13.9	6.5	12.0	5.5	13.0	6.7	2.5	1.9	2.6	1.3
Vitamin A, Trial I																
Injected wethers	41.8	5.8	39.5	5.1	40.3	10.5	40.3	3.2			40.4	5.9				
Control wethers	43.0	8.1	45.8	8.2	45.4	6.9	39.5	7.4			41.8	6.2				
Vitamin A, Trial II																
Injected wethers	36.0	3.2	35.8	4.8			40.5	2.2			37.3[c]	1.7				
Control wethers	46.0	7.1	44.4	7.3			46.9	7.4			46.0[c]	5.9				

[a] Expressed as mcg. per 100 ml. plasma and standard deviation from the mean.
[b] Expressed as mcg. per gm., fresh basis.
[c] Blood withdrawn 19 hours after treatments.
[d] Two days after treatment.

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EXCRETA COLLECTION APPARATUS FOR WETHERS[1]

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COLLECTION of excreta from sheep for chemical anaylsis is an integral part of many investigations. The major concern in constructing excreta collecting devices is (1) their adaptability to particular types of studies and (2) ease of adjustment to sheep of various sizes. Bratzler (1951) proposed the use of metabolism crates. Cook *et al.* (1952) described harness and bags for urine and fecal collection from grazing wethers. Dick (1954) reported details of urine collecting apparatus similar in principle to the one described herein.

The apparatus described below has been successfully used at the University of Arizona for urine and fecal collection from wethers and rams of various sizes. It does not require custom construction. The dorsal view of the harness is detailed in figure 1. The back strap (K), adjustable by buckle (F), is made from two-inch, heavy-duty webbing, and the other straps are made from one-inch, light-weight webbing. Strap (B) is fitted around the neck of the sheep, and straps (A) and (L) snap to the anterior and posterior ends of the urinal, respectively. The three straps, at right angles to the back strap, are constructed so that they can be moved forward and backward for adjustment. The terminal ends of straps (G) and (I) are snapped to the lateral parts of the urinal; in each of these straps are sewn 2 inches of elastic to allow for expansion of the harness. Strap (E) is connected over the urinal and about the heart girth of the sheep. Strap (M) is attached to the fecal bag and to the one-inch ring (D) that is sewn to the back strap. Straps (N) and (O) are snapped to the fecal bag and to the one-inch rings (H) and (G), respectively.

The urinal (figure 2, No. 2), which is made for women, was manufactured by the Daval Rubber Company, Providence, Rhode Island. A polyethylene tube can be attached to the urinal as shown in figure 2, No. 2 and 3. If the wether is not previously shorn, wool should be clipped about the penis area to prevent urine absorption by the wool. When a wether (figure 2, No. 3) is placed in a metabolism stall, urine can be directed into a bottle. Further, this method allows the sheep freedom of movement while in the stall. The Daval Rubber Company also manufactures a bladder for use with a urinal designed for men. This bladder, which has a capacity of approximately one liter, is fitted with a flutter valve that allows the urine to flow in only one direction. The bladder can be screwed to the female urinal and attached to the sheep for urine collection (figure 2, Nos. 5 and 6). The bladder, when filled with urine, may be emptied readily (figure 2, No. 4).

[1] Arizona Agricultural Experiment Station Technical Paper No. 504.
[2] Department of Animal Science.

This harness and urinal has proven to be economical, versatile, and satisfactory for the collection of urine and feces from wethers and rams in stalls, in pens, and on pasture. Furthermore, excessive irritation from the harness and urinal has not been encountered.

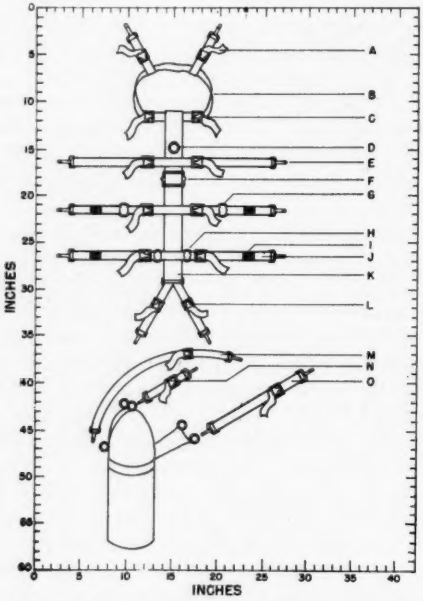

Figure 1. Details of the harness and fecal collection bag.

Summary

Details of an inexpensive harness, urinal, and fecal bag for collecting excreta from wethers and rams are shown. This apparatus was designed to provide for excreta collection in pens, stalls, or on pasture.

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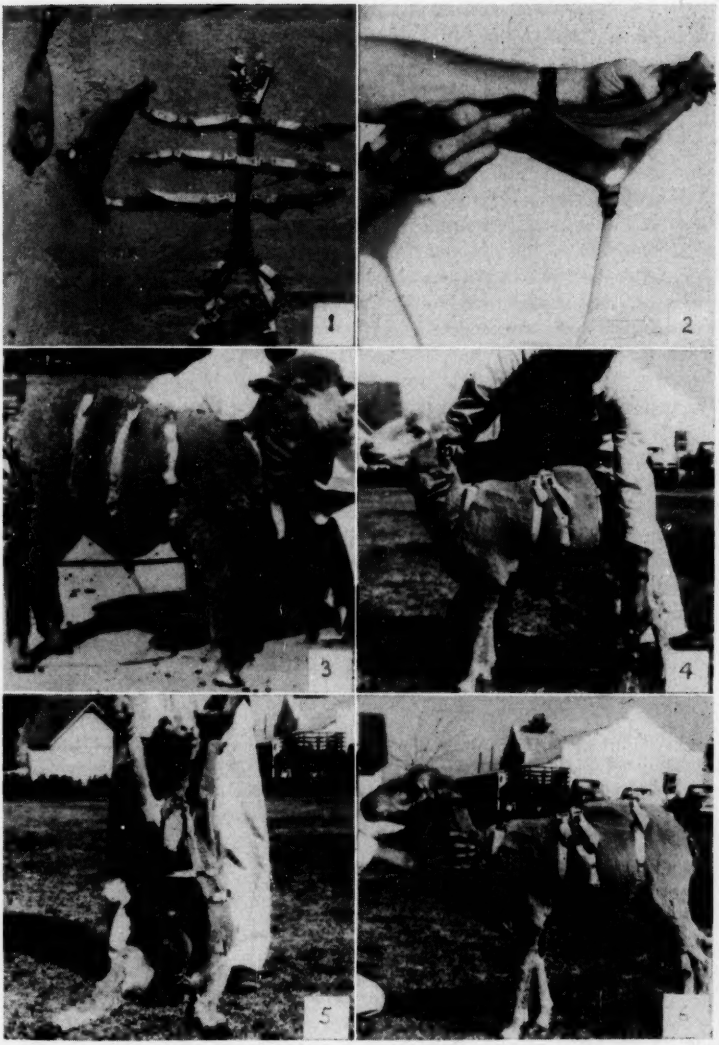

Figure 2. The urinal and harnessed wether. (1) Dorsal view of harness and (2) urinal with tube. (3) Harnessed wether with tube for urine collection in a stall. (4) Collection of urine from the bladder attached to the urinal. (5) Ventral view of urinal with attached bladder. (6) Side view of harnessed sheep with bladder attached to the urinal.

RELATIONSHIPS AMONG FACTORS ASSOCIATED WITH MOTHERING ABILITY IN BEEF CATTLE [1, 2]

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MANY factors contribute to the development of a calf in such a way as to influence the apparent mothering ability of its dam. The definition of all contributing factors and relationships among them under our present systems of beef production has not been clarified. The emphasis in recent years on improvement of mothering ability through selection programs increases the importance of information concerning factors associated with mothering ability.

There are indications that milk production in beef cows is limited by the capacity of the calf (Gifford, 1949, 1953) and that maximum production is reached about 4 weeks post partum (Cole and Johansson, 1933). Milk production and mothering ability of a cow as expressed in weaning weight of calf increases with age up to the approximate age of maturity which varies somewhat from herd to herd. (Koch and Clark, 1955; McCormick *et al.*, 1956; Brown, 1958). These and other studies also indicate the importance of the effects of sex of calf, year and season of birth, sires, inbreeding and other factors on mothering ability in beef cattle. (Clark *et al.*, 1958; Stonaker, 1958).

Experimental

Data used to study relationships were the milk records, calf weights and suckling behavior of purebred Aberdeen-Angus cows and calves maintained at the University of Arkansas Agricultural Experiment Station at Fayetteville. In 1957 milk records were obtained on March 21, May 17, and September 19. The 27 calves observed ranged from 3 to 36 days of age at first sampling.

In 1958 the milk records were obtained on March 12, May 15 and Sept. 17. The 21 calves observed in 1958 ranged from 6 to 38 days of age at the first sampling. Thus in both years the differences in age among the calves were less than those commonly observed among calves born during a calving season. Age of calves on the date that milk production was estimated would thus vary by approximately one month but the interval between dates that milk production was estimated would be constant for all calves. Eight cows had calves in both years.

Milk production of each cow was estimated for one day in the first,

[1] Published with the approval of the Director of the Arkansas Agricultural Experiment Station.
[2] A publication of the Southern Regional Beef Cattle Breeding Project, S–10.

third, and sixth months of lactation through use of differences in calf weights taken immediately before and after nursing. Calves were maintained with their dams on pasture except at times of estimating milk production. About mid afternoon of the day prior to estimating milk production the calves were separated from their dams for a period of about 2 to 3 hours. This preliminary separation was to insure that cows would be suckled out just prior to the time they were separated from their calves at 6 p.m. on the day before estimating milk production. On the day that milk production was estimated the calves were allowed to nurse beginning at 6 a.m. They were separated immediately afterwards and allowed to nurse again at 4 p.m. Approximately 2 hours were required to obtain records for all calves. Care was taken that calves were suckled in the same order in the morning and evening. The daily milk production was thus estimated for a period which was approximately 22 hours from the sum of the weight increases at the two nursing times. After calves finished nursing, the cows were checked for additional milk, but none was found except in some heavier producing cows during the first month.

When approaching the cow for the first time following parturition, the herdsman assigned a score for attentiveness of dam toward her offspring. This score referred to herein as the mothering score ranged from 1 to 3. One was assigned to cows which were very nervous and would fight, 2 was assigned to cows which were attentive, but would not fight, and 3 was assigned to cows which would claim the calf, but were not particularly attentive.

Observations of cow and calf behavior were made 3 days after milk records were taken. To aid in identification the dam's tattoo number approximately 6 inches high, was stenciled on each cow and calf with white paint. The cows and calves were divided into two groups and placed in two small pastures about 4 acres in size. In these pastures, it was possible with binoculars to observe the nursing and suckling behavior without disturbing the cattle. Observations began at daybreak and terminated at dusk. The observation periods were approximately 13 hours, 16 hours and 12 hours for March, May and September, respectively. Preliminary observations indicated that unless disturbed the suckling of calves during the night was negligible.

Lactation number, birth weight and age of calf were obtained from permanent herd records. Total gains from birth, gain between sampling periods and pounds of milk required per pound of gain were calculated using the morning or shrunk weight of the calf. Pounds of milk required for a pound of gain was estimated for each calf by multiplying the number of days since birth or the date of the previous sample by the estimate of daily production and dividing by the gain made during the period under consideration.

TABLE 1. MEANS AND STANDARD DEVIATIONS OF CHARACTERS RELATED TO MOTHERING ABILITY

Item	Months in lactation		
	First	Third	Sixth
	1957 observations		
Number of calves observed	27[a]		
Lactation no. of dam	2.6(1.6)[b]		
Mothering score	2.1(0.8)		
Birth wt. of calf, lb.	58 (8.0)		
Calf wt. at sampling, lb.	81 (15.9)	166 (26.2)	334 (34.5)
Total gain from birth to sampling, lb.	23 (15.0)	108 (24.2)	276 (32.4)
Gain from last sample, lb.		45 (7.4)	168 (16.5)
Age of calf, days	17 (11.5)	74 (11.5)	198 (11.1)
Av. da. milk prod. of dam, lb.	14.5(3.6)	17.2(3.6)	9.1(2.2)
Lb. milk/lb. gain	14.0(11.1)	11.6(2.8)	6.8(1.7)
Total time suckled, min.	38.5(16.5)	66.7(17.5)	33.2(8.1)
No. times suckled	4.7(1.8)	6.0(1.6)	3.1(0.7)
Interval between suckling, min	180 (17.6)	169 (44.7)	327 (102.2)
	1958 observations		
Number of calves observed	21		
Lactation no. of dam	2.5(2.0)		
Mother score	2.1(0.7)		
Birth wt. of calf, lb.	55 (8.9)		
Calf wt. at sampling, lb.	77 (9.5)	165 (20.4)	364 (40.8)
Total gain from birth to sampling, lb.	22 (11.6)	110 (19.2)	309 (39.2)
Gain from last sample, lb.		43 (8.2)	199 (22.3)
Age of calf, days	20 (10.7)	84 (10.7)	209 (10.7)
Av. da. milk prod. of dam, lb.	13.6(3.9)	14.4(4.2)	8.9(2.8)
Lb. milk/lb. gain	10.5(4.1)[c]	9.7(2.4)	5.6(1.6)
Total time suckled, min.	39.3(20.5)	42.0(10.4)	27.7(10.7)
No. times suckled	4.5(1.3)	3.2(0.7)	2.9(0.8)
Interval between suckling, min.	207 (87.5)	357 (127.6)	332 (119.7)
	Average		
Number of calves observed	48[d]		
Lactation no. of dam	2.6(1.8)		
Mothering score	2.1(0.7)		
Birth wt. of calf, lb.	57 (8.4)		
Calf wt. at sampling, lb.	79 (13.5)	165 (23.8)	348 (37.4)
Total gain from birth to sampling, lb.	23 (13.6)	109 (22.1)	291 (35.6)
Gain from last sample, lb.		44 (7.8)	182 (19.3)
Age of calf, days	18 (11.1)	78 (11.1)	203 (10.9)
Av. da. milk prod. of dam, lb.	14.1(3.7)	16.0(3.9)	9.0(2.5)
Lb. milk/lb. gain	12.5(10.8)[e]	10.8(2.6)	6.3(1.6)
Total times suckled, min.	38.8(18.4)	55.9(14.8)	30.7(9.4)
Number times suckled	4.6(1.4)	4.8(1.3)	3.0(0.8)
Interval between suckling, min.	192 (81.8)	251 (90.6)	329 (110.3)

[a] Six-month average obtained from only 26 cows.
[b] Number in parentheses is the standard deviation.
[c] Only 20 records available to compute this average.
[d] Six-month average obtained from only 47 cows.
[e] Only 47 records available to compute this average.

Results and Discussion

In table 1 are shown the average observations and the standard deviations of measurements indicating growth, milk production and behavior. The average weights and gains are similar in the two years as might be expected since management of the cows and calves was similar. The average daily milk production was slightly higher in 1957 than in 1958 and was consistent with the age difference between the groups of cows observed. The estimates of milk production obtained by weight differences of calves appeared comparable to those reported by Cole and Johansson (1933) and by Gifford (1949, 1953) by hand-milking for Aberdeen-Angus cows.

The differences between months in the average total time spent suckling were not as pronounced in 1958 as in 1957, but were in the same direction. Averages indicate that after calves reached a certain age the time spent suckling decreased. In these data the total time suckled was greatest at three months. The average duration of suckling, when data from both years were combined was 8.4, 11.6 and 10.2 minutes for the first, third and sixth months, respectively. The observations made at 6 months of age may have been slightly distorted by the fact that in 1958 two cows were in heat on the day of observation. However, in other unpublished data from the Arkansas station the time spent suckling increased to about 6 weeks of age and declined thereafter until weaning. In these data the average number of times suckled per day was 4.6, 4.8 and 3.0 times for the first, third and sixth months, respectively. Munro (1955) observed that duration and frequency of suckling decreased as lambs increased in age. Sojetado (1952) observed the average duration of suckling to be the greatest when lambs were from 1 to 15 days of age.

When observations from both years were combined the estimated milk required to make a pound of gain was 12.5, 10.8 and 6.3 in the first, third, and sixth months of lactation, respectively. No other estimates of efficiency of beef calves prior to weaning have come to the attention of the authors. These values for first and third month are similar to values that may be calculated from the milk production and gains reported by Gifford (1953). Since the calves were on pasture with their dams at all times the amount of forage consumed in addition to milk is unknown. The milk required per pound of gain during the first and third months is similar to that which has been reported for dairy calves by Eckles and Anthony (1950) and Willard (1948), and would suggest that the forage taken by the calves during early life was small in amount. Owen (1957) noted a steady decrease in ounces of milk required per ounce of live weight increase as lambs increased in age.

The similarity of the standard deviations in table 1 indicates that the cows studied in both years were quite uniform in production. In general, less variability was noted in milk production for the 1957 observations. This would be consistent with the age differences noted.

TABLE 2. INTRA-YEAR CORRELATIONS AMONG FACTORS RELATED TO PRE-WEANING GROWTH AND BEHAVIOR OF BEEF CATTLE[a, b]

Item	Symbol	Months in lactation	B	C	D	E	F	G	H	I	J	K	L
Lactation number		1	—.40	0.32	0.24	0.04		—.11	0.49	0.07	0.06	0.11	0.00
	A	3			0.35	0.25	0.25		0.56	0.39	0.03	—.16	0.38
		6			0.42	0.36	0.38		0.06	—.10	0.31	—.22	0.31
Mothering score		1		—.16	0.00	0.10		0.25	—.43	0.05	0.04	—.05	0.03
	B	3			—.17	—.13	—.23		—.48	—.34	—.11	0.08	—.18
		6			—.20	—.28	—.36		—.05	0.07	—.10	0.02	—.13
Birth wt. of calf		1			0.30	—.32		—.50	0.43	0.17	—.27	—.22	0.11
	C	3			0.37	0.02	0.27		0.29	0.12	0.04	—.23	0.29
		6			0.32	0.10	0.17		0.12	0.07	0.14	—.20	0.27
Calf wt. at sampling		1				0.81		0.56	0.12	—.28	0.39	0.28	—.20
	D	3				0.94	0.80	0.28	0.43	—.18	—.18	—.27	0.16
		6				0.97	0.83	0.16	0.46	0.20	0.16	0.02	—.02
Total gain from		1						0.86	—.15	—.38	0.55	0.43	—.26
birth to sampling	E	3					0.75	0.50	0.35	—.24	0.29	—.21	0.06
		6					0.83	0.30	0.48	0.19	—.03	0.07	0.09
Gain from last sample		1											
	F	3						0.07	0.45	—.33	—.28	—.24	0.13
		6						0.03	0.29	—.06	—.14	—.06	0.00
Age of calf		1							—.37	—.28	0.59	0.40	—.23
	G	3							—.33	—.44	—.16	0.01	—.27
		6							—.02	0.02	0.01	0.28	0.06
Av. da. milk		1								0.35	—.40	—.30	0.34
prod. of dam	H	3								0.68	0.03	—.18	0.30
		6								0.93	0.21	0.22	—.02
Lb. milk/lb. gain		1									—.28	—.23	0.23
	I	3									0.32	0.05	0.20
		6									0.18	0.27	—.03
Total suckling time		1										0.74	—.60
	J	3										0.70	—.42
		6										0.58	—.29
Number times sucked		1											—.77
	K	3											—.54
		6											—.73
Interval between suckling		1											
	L	3											
		6											

[a] Correlations of 0.28 significant, $P<.05$; correlations of 0.37 significant, $P<.01$, during 1st and 3rd months.
[b] Correlations of 0.29 significant, $P<.05$; correlations of 0.37 significant, $P<.01$, during 6th month.

Intra-year correlations among factors related to the pre-weaning growth and behavior of beef calves for 1, 3 and 6 months are shown in table 2. These were obtained by pooling sum of squares and cross products. Highly significant correlation coefficients indicate a negative relationship between mothering score and both lactation number and average daily milk production of the dam. These values suggest that older cows were more protective and were heavier milk producers. This would be consistent with observations of other workers. Gifford (1949, 1953) observed that maximum milk production for Hereford cows was attained at 6 years of age. Observations of other workers (Knox and Koger, 1945; Koch, 1951; McCormick *et al.*, 1956; Clark *et al.*, 1958; Brown, 1958) indicate that, in general, the age-of-dam effect has been considered as a curve with maximum weaning weights expected soon after maturity is reached. The correlation of 0.32 between birth weight of calf and lactation number of dam indicates that older cows also gave birth to heavier calves. A correlation of 0.53 was observed by Dawson *et al.* (1947) between age of the dams and birth weight of their calves.

The correlation between birth weight of the calf and age of the calf at sampling was —.50. Thus calves with heavier birth weights were younger at the time of sampling. This would be expected if heavier calves were born later in the calving season as reported by Koch and Clark (1955).

Correlation coefficients between average daily milk production of the dam and birth weight of the calf were 0.43, 0.29 and 0.12 for the first, third and sixth months, respectively. These values would indicate a positive relationship between higher milk records and larger calves at birth. This relationship appears to decrease as the lactation progresses. These values would be consistent with findings of Gifford (1949, 1953) in which it was observed the milk production of the dams was limited to the capacity of the calf to consume the milk. They would suggest that toward the end of the suckling period the calf may be able to compensate to some extent for a lighter birth weight. Owen (1953) observed a correlation of 0.51 between the milk yield of ewes and the birth weight of single lambs. Burris and Baugus (1955) noted a correlation value of 0.50 between total milk produced and birth weight of lambs from aged Hampshire ewes.

The correlation values between birth weight and calf weight at sampling were 0.30, 0.37, and 0.32 for the first, third and sixth months, respectively. The magnitude of these values would suggest that heavier calves at birth were able to maintain their weight advantage through 6 months. Gregory *et al.* (1950) reported correlation values of 0.27 and 0.60 between the birth weight and the weaning weight of calves at the North Platte and Valentine Stations.

The correlation values between age of calf and calf weight at sampling were 0.58, 0.28, and 0.16. Correlations between age of calf and total gain

from birth were 0.86, 0.50, and 0.30. Such correlation values indicate that during the first month the older calves were heavier, but as the lactation progressed the calves born earlier tended to loose their advantage in weight. Thus, differences in age, even in uniform age groups, may be large enough to obscure important relationships measured by gain or weight early in the lactation. For example, the correlations between total gain from birth and estimated daily milk production of the dam were —.15, 0.35, 0.48 for first, third and sixth month, respectively, and would suggest that this relationship may be influenced by age of calf. These values would indicate that even though the relationship was negative at one month, calves suckling heavier producing dams made greater total gain by the third and sixth month. These correlations are lower than those reported by Gifford (1949, 1953) and Knapp and Black (1941) between rate of gain by beef calves and the milk production of their dams. Studies with sheep indicate that correlation values between milk production of the ewe and gains of lambs, from birth to weaning, range from 0.6 to 0.9.

In general, the correlation values between pounds of milk required per pound of gain and pre-weaning growth and behavior data indicated that calves suckling higher producing dams made the least gain from a given volume of milk. Such a relationship could arise from the fact that heavier calves which were suckling heavier producing dams would have higher maintenence requirements, or there may have been differences in the fat content of milk. Procedures used in obtaining the milk samples prohibited a reliable estimate of the butterfat percentage.

The size and sign of the correlations at one month would indicate that those heavier and older calves, suckling lower producing dams, suckled more frequently and spent more time suckling. However, by the sixth month, calves suckling heavier producing dams tended to suckle more frequently and spend more time suckling.

Multiple correlations and standard partial regressions were computed for the first, third, and sixth month of lactation using total gain of the calf from birth as the dependent variable and six of the variables most commonly associated with mothering ability of the beef cow as independent variables. Total gain of the calf from birth was chosen as the dependent variable to measure mothering ability. Total gain would measure the total accumulated product (beef) of a cow as a result of her mothering ability on any day in the lactation that might be chosen to compare her with her contemporaries. The independent variables were lactation number, mothering score, estimated daily milk production of the dam, birth weight, age, and suckling time of the calf. Highly significant R's in table 3 indicate that these six variables account for 75%, 77% and 60% of the variability associated with total gain of the calf up to one, three and six months of age, respectively. At one month the most important variable was age of calf; whereas, by three months birth weight, age

of calf, milk production and suckling time significantly affected the total gain. At six months all variables except birth weight significantly affected the total gain. These multiple regression equations indicate that factors other than milk production may contribute to mothering ability as measured by total gain. They also provide evidence that the relationships among factors affecting mothering ability change as the calf grows older.

Summary

Data were obtained on 48 Aberdeen-Angus cows and calves during the spring calving season of 1957 and 1958 to study the relationships among certain factors related to mothering ability in beef cattle.

TABLE 3. STANDARD PARTIAL REGRESSION COEFFICIENTS (BETAS) AND MULTIPLE CORRELATION COEFFICIENTS (R) OF VARIABLES PERTAINING TO TOTAL GAIN OF CALF FROM BIRTH

Month	First	Third	Sixth
Lactation number	0.0064	−.1055	0.3063*
Mothering score	−.0432	−.0184	−.2373*
Birth weight	0.0826	0.3188**	0.2073
Age of calf	0.9165**	0.9148**	0.5054**
Milk production	0.1728	0.5977**	0.4953**
Suckling time	0.1021	0.4068**	−.2868*
Multiple R	0.8672**	0.8758**	0.7716**
R_a	0.7521	0.7670	0.5953

* Values are significant ($P<.05$).
** Values are highly significant ($P<.01$).

Highly significant correlations indicate a negative relationship existed between mothering score and both lactation number and average daily milk production of the dam. These values indicate that older cows were more protective and were heavier milk producers. Heavier calves were from older cows and were born later in the calving season.

Calves suckling heavier producing cows made larger total gains from birth to six months, but required more milk per pound of live weight gain.

Older calves suckling lighter producing dams spent more time suckling and suckled more frequently at one month. However, there was a tendency for calves suckling heavier producing dams to spend more time suckling and to suckle more frequently at six months.

Multiple correlations and standard partial regression coefficients would indicate that factors other than milk production may contribute to mothering ability, as measured by total gain of the calf. In these data, lactation number, mothering score, average daily milk production of the dam, birth weight, age, and suckling time of the calf accounted for 75%, 77%, and 60% of the variability associated with total gain of the calf up to one, three and six months of age, respectively. These values also

provide evidence that the relationships among factors associated with mothering ability change as the calf increases in age.

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A COMPARISON OF CERTAIN BLOOD CONSTITUENTS OF DWARF-CARRIER AND NON-CARRIER CATTLE [1]

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FOR a number of years research workers have been conducting investigations in search of anatomical, physiological or chemical factors which could be used to differentiate between dwarf-carrier and non-carrier cattle. To aid in this search investigations were undertaken on certain blood constitutents of non-carrier cattle and of carriers of the gene for dwarfism described by Johnson *et al.* (1950).

The literature reveals only limited information on the blood constituents of dwarfs and dwarf-carrier animals as compared with those of non-carrier animals. Studies by Fransen and Andrews (1954), Andrews *et al.* (1956) and Cornelius *et al.* (1956) indicated that the formed elements of the blood were similar in dwarf and normal cattle. Foley *et al.* (1956) reported cell counts and blood sugar levels were similar in dwarf-free and carrier cattle, but that changes due to insulin shock were different in the two genotypes.

A study by Leuchtenberger *et al.* (1956) showed that the desoxyribonucleic acid (DNA) content of individual spermatogenic cells from one dwarf and two suspected carriers was markedly deficient as compared with corresponding cells of normal bulls. After reviewing Leuchtenberger's study, it was anticipated that the variation in the DNA content of the dwarf and suspected dwarf-carrier sperm cells might be due to the DNA content of the protein other than that of the chromosomes. Therefore, an investigation on the DNA content of the plasma protein was included along with other blood constituents.

Experimental Procedure

Hematology. Hemoglobin, hematocrit, mean corpuscular volume and mean corpuscular hemoglobin determinations were made on blood samples obtained from four different age groups of cattle. Also, erythrocyte (R.B.C.) and leucocyte (W.B.C.) counts were made on the individuals from the same four groups. The groups consisted of: (1) 20 mature Hereford females of which 10 were of known dwarf-carrier and 10 were of assumed non-carrier genotype; (2) 12 three-year-old Hereford heifers which were the offspring of carrier parents or closely related individuals and 7 three-year-old Hereford heifers which were assumed to be non-carriers; (3)

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6 two-year-old Hereford heifers which were the offspring of carrier parents or individuals closely related to carrier animals and 14 two-year-old Angus heifers which were assumed to be non-carriers; (4) 6 yearling Hereford heifers whose parents were carrier animals and 6 yearling Hereford heifers which were from parents assumed to be free of the dwarf trait. The determinations and counts made in this study were in accordance with the procedures suggested by Kolmer, Spaulding and Robinson (1951) and Hawk, Oser and Summerson (1948).

Cell Fragility. A fragility study using the method described by Fulton (1947) was made on erthyrocytes obtained from 28 mature Hereford females, of which 14 were carriers of the snorter dwarf gene and 14 were assumed to be non-carriers.

Serum Protein Fractionation. Serum protein contained in blood serum, which had been obtained from nine snorter dwarf-carrier and five assumed non-carrier mature Hereford females, was broken down into the various globulin fractions by the use of paper electrophoresis described by Block, Durrum and Zweig (1955). After the electrophoresis strips were processed, the various globulin fractions were graphed according to their density by the use of a densitometer. The graphs were compared to determine whether a difference existed in the serum obtained from assumed non-carrier cattle when compared with that obtained from the dwarf-carrier cattle.

Amino Acid Determination. Two dimensional chromatograms were run, in accordance with the procedure described by Levy and Chung (1953), on plasma protein hydrolysates obtained from 12 mature Hereford females of known genotype. Comparisons were made between six hydrolysates obtained from dwarf-carrier and six obtained from assumed non-carrier animals.

Nucleic Acid Determination. Desoxyribonucleic acid (DNA) and ribonucleic acid (RNA) determinations were made on plasma protein samples obtained from 45 assumed non-carrier and 45 snorter dwarf-carrier animals. The procedure used for separating proteins and for analysis was a modification of the cold perchloric acid method described by Ogur and Rosen (1950). The modification was that 3 ml. of plasma obtained from citrated blood was used rather than a given amount of homogenized animal tissue. Six replicate determinations were made on each of 18 cows of assumed genotype in March, July and November of 1957 and in January and March of 1958. Comparisons of the data were made using the method for analysis of variance described by Snedecor (1955).

Zinc and Copper Determinations. Determinations of the zinc and copper content of blood samples obtained from 10 snorter dwarf-carrier and 10 assumed non-carrier mature Hereford females were made by the use of the zincon method described by McCall (1956).

Statistical comparisons between animals which were assumed non-

TABLE 1. MEAN VALUES OF BLOOD CONSTITUENTS OBTAINED FROM DWARF CARRIER AND NON-CARRIER CATTLE OF DIFFERENT AGES

Age	Genotype	Number of animals	R.B.C.'s × 10^6/c.c.	W.B.C.'s × 10^3/c.c.	Hematocrit, vol. %	Hemoglobin, gm./100 ml.	Corpuscular volume[a]	Corpuscular hemoglobin[b]
Yearling	carrier	6	8.16	9.26	42.20	10.87	53.01	13.81
	clean	6	7.70	9.70	44.37	11.44	58.26	15.07
2-year-old	carrier	6	6.76	10.56	44.74	11.70	66.18	17.31
	clean	14	6.69	10.29	46.87	11.57	70.05	17.29
3-year-old	carrier	12	5.73	9.13	39.94	10.40	69.62	18.02
	clean	7	6.03	8.10	37.62	10.74	62.60	17.84
Mature	carrier	10	4.52	7.26	37.95	13.01	83.96	28.78
	clean	10	4.72	6.98	35.10	13.20	74.36	27.97
Unweighted group mean	carrier	—	6.29	9.05	41.21	11.49	68.19	19.48
	clean	—	6.29	8.77	40.99	11.71	66.31	19.54

[a] Cubic microns per corpuscle.
[b] Micro-micrograms per corpuscle.

carriers and those which were known carriers or suspected carriers within the four groups were made. The analysis of variance technique described by Snedecor (1955) was used.

Results and Discussion

Hematology. Hemoglobin, mean corpuscular hemoglobin and hematocrit determinations along with erythrocyte and leucocyte counts from carrier and assumed non-carrier animals were not significantly different. The analyses of variance for these comparisons are shown in table 3. The mean values for the four age groups are shown in table 1.

Mean corpuscular volume was significantly larger (P=0.05) in the carrier group. This indicates that the erythrocytes obtained from the

TABLE 2. GLOBULIN AND ALBUMIN FRACTIONS IN PERCENT OF SERUM PROTEIN OBTAINED FROM DWARF-CARRIER AND NON-CARRIER CATTLE

Genotype	No. of animals	Globulin fractions				Albumin
		Gamma	Beta	Alpha 1	Alpha 2	
Carrier	9	8.6	19.80	19.2	11.3	43.9
Non-carrier	9	9.8	16.47	21.6	12.6	38.4

carrier cattle are larger than those obtained from the non-carrier group. This observation has not previously been reported, therefore further study with additional replications on this factor at different locations and seasons of the year should be made to substantiate this finding. Although there were no significant differences in the other blood elements between genotypic groups within the same age group, a highly significant difference (P=0.01) was apparent between age groups. In some cases a significant difference was noted between replications within a specific age group. Studies by Fransen and Andrews (1954), Andrews *et al.* (1956) and Cornelius *et al.* (1956) showed that the formed elements of the blood were similar in dwarf and normal cattle. However, mean corpuscular volume was not studied.

Cell Fragility. Statistical analysis of the results obtained from 14 dwarf-carriers and 14 assumed non-carriers did not show a significant difference. The mean value for the non-carrier group was 0.43 as compared to 0.41 for the dwarf-carrier group.

Serum Proteins. The various globulin fractions and the serum albumin portion of the serum protein obtained from dwarf-carrier and non-carrier animals were comparable. The mean values for the two genotypic groups are shown in table 2. The analyses of variance for these data are shown in table 4. Cornelius *et al.* (1956) showed that the protein level of serum obtained from snorter type dwarfs was within the normal range. It

TABLE 3. ANALYSES OF VARIANCE SHOWING MEAN SQUARES FOR THE COMPONENTS OF THE BLOOD FROM DWARF-CARRIER AND NON-CARRIER ANIMALS

Source	df	R.B.C.'s	W.B.C.'s	Hemoglobin	Hematocrit	Mean corpuscular volume	Mean corpuscular hemoglobin
Replications	1	2.4181**	0.760*	0.219	12.373*	220.670**	47.060**
Genotype	1	0.3422	0.029	0.016	0.907	67.000*	0.865
Age	3	4.8966*	7.227**	4.570**	31.488**	273.880**	75.295**
Replication x genotype	1	0.0097	2.640**	0.069	30.979**	51.660	1.428
Replication x age	3	1.3061**	2.629**	2.084**	0.668	254.430**	29.818**
Genotype x age	3	0.0399	0.127	0.305	2.980	24.510	0.236
Replication x genotype x age	3	0.1939	0.187	0.046	11.743*	19.780	0.172
Error (coded)	126	0.1176	0.182	0.186	3.008	17.112	3.313

K=8.937.
* Significant P=0.05 or less.
** Highly significant P=0.01 or less.

appears that the various fractions of the serum protein are not affected by the genotype of the animal as far as the dwarfism trait is concerned.

Amino Acids. Two dimensional chromatograms made from hydrolyzed plasma protein obtained from six dwarf-carrier and six non-carrier animals revealed that the same 16 amino acids were present in each group. No attempt was made to measure quantitatively the amounts of the various amino acids present.

Nucleic Acids. The mean values for desoxyribonucleic acid (DNA) and ribonucleic acid (RNA) obtained from blood plasma of 45 dwarf-carrier animals was 7.43 and 3.58 mcg./ml. respectively. The corresponding mean values from 45 non-carrier cows were 5.97 and 4.33 mcg./ml. The RNA content of the plasma protein obtained from dwarf-carrier cattle was significantly higher (P=0.05) than that of non-carrier cattle. A highly significant difference (P=0.01) was noted between the DNA content of the plasma protein obtained from dwarf-carrier and non-carrier cattle (table 5). Even though a highly significant difference was apparent between the amounts of DNA contained in samples obtained from two groups, there was an area of overlap between them. Also, a significant difference among replicates at different seasons of the year was observed. The feasibility of using the DNA content of plasma protein for differentiat-

TABLE 4. ANALYSES OF VARIANCE SHOWING THE MEAN SQUARES FOR THE GLOBULIN AND ALBUMIN CONSTITUTENTS OF THE SERUM PROTEIN

Source	df	Gamma	Alpha 1	Alpha 2	Beta	Albumin
Genotype	1	0.35	22.43	0.12	29.90	15.31
Error	16	5.32	11.48	4.50	13.78	19.24

ing carrier and non-carrier animals appears rather dubious due to the overlap.

Determinations of the amount of RNA were made on the same blood samples used for the DNA study. The amounts of RNA extracted from the samples of plasma protein obtained from the dwarf-carrier group were significantly higher (P=0.05) than those from the non-carrier group. There exists a certain amount of overlap between the RNA content of these groups as was the case with the DNA. Apparently the amount of RNA present was more nearly constant than the DNA at different seasons of the year, since there was no significant difference among replications.

TABLE 5. ANALYSES OF VARIANCE SHOWING THE MEAN SQUARES OF THE PLASMA PROTEIN LEVELS OF DNA AND RNA AND BLOOD LEVELS OF CU AND ZN IN DWARF-CARRIER AND NON-CARRIER COWS

	Plasma protein levels			Blood levels		
Source	df	DNA	RNA	df	Cu	Zn
Replications	4	257.19**	198.25	1	0.8122	3.721
Genotype	1	57.92**	459.72*	1	0.7562	0.004
Replication x genotype	4	4.40	307.41*	1	0.0063	0.576
Error	80	1.82	110.75	36	0.2612	0.998

* Significant P=0.05 or less.
** Highly significant P=0.01 or less.

Further research on the amount of RNA or DNA in various tissues, along with improved methods of extraction and measurement, might bring forth a more clear-cut difference than was shown in this study.

Zinc and Copper. Zinc and copper determinations made on blood samples obtained from dwarf-carrier and non-carrier cattle showed that the levels of these two minerals evidently are not affected by the genotype of the animal. The blood levels of zinc and copper were not measured in the dwarf. A summary of these comparisons is shown in table 5.

Summary and Conclusions

The hematology portion of this study indicated that the erythrocytes obtained from the snorter dwarf-carrier animals were larger than those obtained from non-carrier animals. This was indicated by a significantly higher (P=0.05) mean corpuscular volume in the dwarf-carrier group.

The RNA content of the plasma protein was significantly higher (P=0.05) in the dwarf-carrier group. The DNA content of the plasma protein was higher in the non-carrier group than in the dwarf-carrier group. This difference was highly significant (P=0.01).

Non-significant differences between carrier and non-carrier groups were observed for the following items: Blood hemoglobin, mean corpuscular

hemoglobin, hematocrit, erythrocyte number, leucocyte number, blood cell fragility, blood serum albumin, blood globulin fractions, blood copper, and blood zinc levels. The same 16 amino acids were present in blood plasma. Quantitative amino acid determinations were not attempted.

Even though certain factors considered in this study exhibited a significant or highly significant difference, the feasibility of using one or more as a detector of carriers of the dwarf gene is rather doubtful. In all cases there were varying degrees of overlap between the two groups which prevented differentiation of the dwarf-carrier and non-carrier with an acceptable degree of accuracy.

The differences observed in this study have not been previously reported. Further study with additional replications on these factors at different locations and seasons of the year should be made to substantiate and enlarge upon these findings.

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DEAMINATION OF AMINO ACIDS *IN VIVO* BY RUMEN MICROORGANISMS [1]

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THE utilization of nitrogen compounds in ruminants is influenced by three processes: (a) The conversion of dietary protein to microbial protein; (b) the release of ammonia from dietary protein and non-protein nitrogen sources and the subsequent absorption of a portion of that ammonia through the rumen wall; and (c) the synthesis of microbial protein from non-protein nitrogen sources (Chalmers and Synge, 1954). Limited information is available on the deamination of amino acids in the rumen. El-Shazly (1952) observed that the amino acids of an acid hydrolysate of casein were deaminated by washed suspensions of rumen microorganisms, and that the amount of deamination depended on the diet of the animals. Sirotnak *et al.* (1953) reported the decarboxylation and deamination of aspartic acid, glutamic acid, serine, arginine, cysteine and cystine by bovine rumen bacteria. Warner (1956), Nikitin (1939) and Pearson and Smith (1943) have demonstrated proteolysis by rumen microorganisms. Warner (1956) observed that both rumen bacteria and protozoa are proteolytic and that ammonia appears to be the end product of their metabolism. A later study was conducted by Sirotnak *et al.* (1954) on aspartate dissimulation reactions of rumen bacteria. The principal pathway of decomposition of aspartate appeared to be a deamination to succinate, decarboxylation to propionate, and further conversion to acetate and butyrate. Hueter *et al.* (1958) compared *in vivo* and *in vitro* techniques in studies of the deamination of DL-aspartic acid, DL-lysine and glycine. Both *in vivo* and *in vitro* data indicated that little or no volatile fatty acids were produced from DL-lysine. A mixture of glycine plus DL-alanine was deaminated *in vivo* by rumen microorganisms. The *in vivo* deamination of DL-aspartic acid was also observed. The present study reports the deamination in the rumen of certain amino acids fed individually in amounts sufficient to supply the nitrogen requirement of a mature steer.

Materials and Methods

An eight-year-old Holstein steer fitted with a plastic rumen fistula plug was fed a basal diet consisting of 18 lb. cottonseed hulls and 3.33 lb. molasses twice daily at 6 a.m. and 6 p.m. Water and a mineral mix of equal parts dicalcium phosphate and salt were available at all times except

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TABLE 1. THE LEVEL OF NITROGEN IN THE RUMEN LIQUOR OF A FISTULATED STEER FED VARIOUS AMINO ACIDS [a]

Diet	Hours after feeding												
	0	1	2	3	4	5	6	7	8	9	10	11	12
Total nitrogen in rumen liquor													
Basal [b]	17.83	25.69	18.34	18.34	24.92	24.92	17.71	17.38	15.46	17.06	16.10	15.78	17.06
Basal and Glycine	48.24	99.95	98.11	90.74	85.56	95.00	81.43	81.75	75.99	70.42	70.18	74.22	69.44
Basal and Glutamic acid	52.86	182.62	143.94	128.92	132.12	112.97	106.55	97.60	75.55	60.53	55.09	64.04	71.08
Basal and Aspartic acid	38.79	120.33	109.43	100.48	97.28	83.86	78.43	63.56	52.86	44.07	39.59	41.19	38.16
Basal and Alanine	41.35	133.40	113.56	107.03	114.54	84.50	79.70	80.34	60.85	55.41	51.90	50.30	52.54
Basal and Lysine	55.89	90.41	81.92	76.51	89.29	85.94	81.31	75.07	73.79	76.03	70.75	68.84	66.28
Protein nitrogen in rumen liquor													
Basal	2.81	9.20	4.09	4.09	4.09	5.36	4.41	3.45	3.13	3.77	4.73	3.45	4.09
Basal and Glycine	17.69	25.34	24.16	15.98	22.17	19.38	15.04	15.70	12.09	10.65	13.42	16.68	15.54
Basal and Glutamic acid	29.33	56.51	25.82	24.86	29.30	25.82	29.02	29.97	22.30	14.79	15.11	25.18	35.09
Basal and Aspartic acid	13.35	26.14	10.48	10.48	13.99	10.80	13.67	11.76	13.03	8.24	7.96	9.52	10.48
Basal and Alanine	17.19	22.75	11.76	13.67	11.44	10.80	11.44	13.35	8.88	10.80	8.56	11.76	13.99
Basal and Lysine	20.09	30.45	16.71	12.08	28.09	23.26	19.91	18.95	19.11	26.78	24.06	20.86	23.42
Non-protein nitrogen in rumen liquor													
Basal	15.02	16.49	14.25	14.25	20.83	19.55	13.29	13.93	12.33	13.29	11.37	12.33	12.97
Basal and Glycine	30.55	74.61	73.94	74.76	63.39	75.62	66.38	66.05	63.90	59.78	56.76	57.54	53.90
Basal and Glutamic acid	23.52	126.11	118.12	104.06	102.81	87.14	77.53	67.63	53.24	45.73	39.98	38.86	35.98
Basal and Aspartic acid	25.44	94.19	98.94	89.99	83.28	73.06	64.75	51.81	39.82	35.82	31.63	31.67	27.67
Basal and Alanine	24.16	110.64	101.80	93.35	103.10	73.69	68.26	66.98	51.96	44.61	43.33	38.54	38.54
Basal and Lysine	35.80	59.95	65.21	64.43	61.20	62.67	61.39	56.12	54.68	49.25	46.69	47.97	42.85
Ammonia nitrogen in rumen liquor													
Basal	1.30	1.90	1.90	2.00	1.30	2.40	1.00	.60	1.70	.60	.70	.40	.40
Basal and Glycine	1.0	1.3	1.25	1.45	1.35	1.35	1.15	1.15	1.50	1.30	1.20	1.20	.80
Basal and Glutamic acid	.65	1.25	2.55	2.70	3.20	4.95	5.20	6.40	7.10	6.68	5.25	2.95	1.60
Basal and Aspartic acid	1.00	2.30	3.30	4.00	3.30	3.05	2.90	2.65	2.35	1.80	1.55	1.50	1.25
Basal and Alanine	1.03	2.20	1.05	1.50	1.60	2.00	2.00	2.70	3.00	2.25	1.55	1.05	1.30
Basal and Lysine	1.20	3.05	1.83	1.15	1.10	1.15	1.10	1.35	1.35	1.30	1.05	.65	.60

[a] Values expressed in mg. of nitrogen per 100 ml. of rumen liquor.
[b] Basal diet consists of 18 lb. cottonseed meal and 3.33 lb. of blackstrap molasses twice daily.

on the days samples were taken. On these days water was removed one hour after feeding and was withheld for the remainder of the 12-hour sampling period.

The steer was fed individual amino acids on an equal nitrogen basis once daily for 3 days, samples of rumen liquor being taken on the third day. The morning feeding of 18 lb. cottonseed hulls and 3.33 lb. molasses supplied 60.82 gm. of nitrogen. Each amino acid, when added, supplied an additional 72.64 gm. of nitrogen. Nicholson *et al.* (1956) have demonstrated that short digestion periods may be used with ruminants if drastic changes

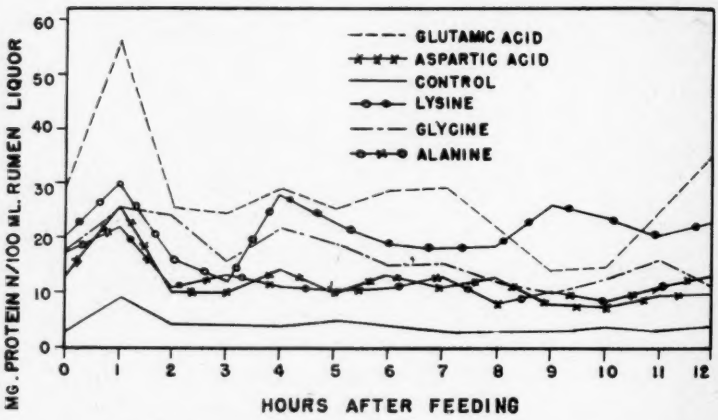

Figure 1. The protein nitrogen level in the rumen liquor of a fistulated steer fed various amino acids.

in rations are not made. On the days collections were made, a rumen liquor sample was taken before feeding and designated the zero hour sample. Further samples were taken at hourly intervals for 12 hours. The samples were taken from the upper and lower levels and also at the anterior and median areas of the rumen. The ingesta was squeezed through two layers of cheesecloth and the liquid was immediately taken to the laboratory for analysis. Total nitrogen was determined by the A.O.A.C. method (1950). Ammonia nitrogen was determined by the method of Conway (1933) and Conway and Byrne (1933). Non-protein nitrogen was calculated as the difference between total nitrogen and the protein nitrogen determined on a protein precipitate of the rumen liquor (Folin and Wu, 1919).

Results

Results of the *in vivo* studies with individual amino acids are summarized in table 1.

The protein nitrogen content of the rumen liquor at the different hours

of sampling is presented in figure 1. Each amino acid reached its peak in protein nitrogen production during the first hour after feeding. L-glutamic acid reached a much higher peak in protein nitrogen production the first hour than the other amino acids; however, after the first hour the protein nitrogen declined until the 10th hour when it again rose sharply.

The rate of ammonia production is presented in figure 2. Analysis of

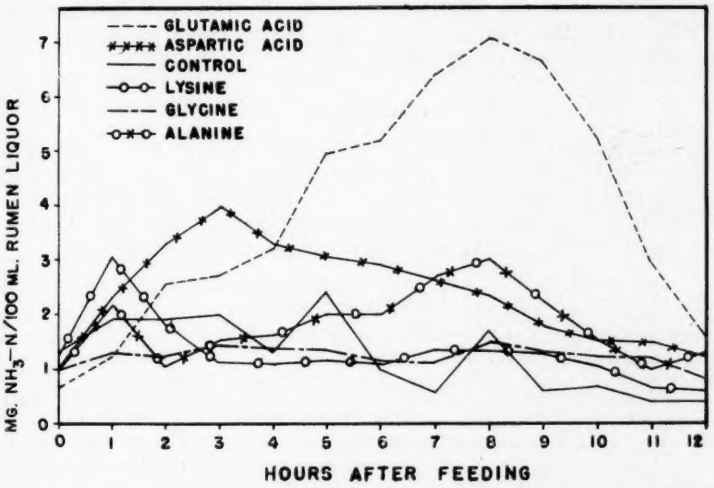

Figure 2. The levels of ammonia nitrogen in the rumen liquor of a fistulated steer fed various amino acids.

variance (Paterson, 1939) showed the amounts of NH_3-N produced with added DL-aspartic acid and L-glutamic acid as compared to the basal were significant at the 1% level. Ammonia production with beta-alanine was significant at the 5% level.

The NH_3-N production with added DL-aspartic acid reached its peak at the third hour after feeding whereas with L-glutamic acid and B-alanine it reached its peak at the eighth hour.

L-lysine reached its peak in NH_3-N production at the first hour, but during the rest of the trial period it did not differ significantly from the control. Glycine was not significantly different from the control at any time during the study.

The peak reached by L-glutamic acid in NH_3-N production was much higher than that reached with either DL-aspartic acid or beta-alanine, but at a later time after feeding. The protein nitrogen in the rumen liquor when L-glutamic acid was fed was maintained at a high level through the study. Comparison of the two levels for glutamic acid shows

that when the protein nitrogen level was at its peak at the first hour, the ammonia level was only beginning to rise. As the NH_3-N level rose gradually to a peak at the eighth hour, the protein level changed very little or decreased. This indicates inefficient utilization of the ammonia.

Although DL-aspartic acid was deaminated significantly, NH_3-N reached a lower peak than that for L-glutamic acid while protein nitrogen showed the same general trend as that for L-glutamic acid.

Ammonia production from beta-alanine, as compared to the basal diet, was significant at the 5% level; protein nitrogen production was not. The need for more studies of this type, utilizing other amino acids and various combinations of them is evident.

Summary

Five individual amino acids, beta-alanine, DL-aspartic acid, L-glutamic, glycine and L-lysine, were fed to a fistulated steer. Significant deamination, as indicated by ammonia production in the rumen, was demonstrated with beta-alanine, DL-aspartic acid and L-glutamic acid. The break down in the rumen of amino acids into ammonia and other materials varies.

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A METHOD FOR THE QUANTITATIVE ESTIMATION OF MARBLING IN THE BEEF RIB EYE MUSCLE [1]

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AN accurate evaluation of meat quality is highly desirable for measuring more satisfactorily the results accomplished through breeding, feeding and management. The degree of marbling is one of the important factors which has been in use for predicting the eating quality of beef. While the exact importance of marbling has previously not been well defined by research studies, it has been given a great deal of emphasis by all persons concerned with beef grades. Recent work has shown, however, that marbling makes some direct contribution to tenderness (Wang *et al.*, 1954; Cover *et al.*, 1956; Cover *et al.*, 1958). Also, Cover *et al.* (1956) concluded that marbling was partly responsible for juiciness.

Until recently, objective techniques for determining the degree of marbling have been lacking. Schoonover and Stratton (1957) used a photographic grid technique for recording the fat, lean and bone of the cut surface of the beef rib. Although Cover *et al.* (1956) reported fairly good success in estimating the amount of marbling expressed as the percentage of fat in the samples, this method of measurement must be considered subjective. Orme *et al.* (1958) showed that specific gravity is a good means of estimating marbling in the longissimus dorsi muscle of the 9–10–11 rib section of the beef carcass. However, only the total fat content is estimated by this method and no information concerning the uniformity of fat deposition is obtained. The method described here is a simple objective means of determining marbling that requires very little special equipment.

Materials and Methods

The 29 samples used to illustrate the technique of intramuscular fat measurement came from cattle fed various combinations of grass and grain. The carcass grades represented here ranged from average good to average choice. Since the treatment effects and the grades of carcasses were not considered pertinent to presenting the method of procedure, they were not included in this paper.

At the time of slaughter, the steers averaged about 16 months of age and weighed about 1100 lb. The feed was withheld for a 24-hour period prior to slaughter, after which they were dressed in a local packing plant and the carcasses chilled at 33° F. for 48 hours. A standard cut Chicago

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style rib was then removed from the right side of each cattle carcass, wrapped to prevent moisture loss, and transported to the college meats laboratory.

For this study a sample one-half inch thick was removed in cross-section from the whole rib eye muscle surface at the 8th rib area. The sample was then immediately placed under the magnifying glass of a colony counter normally used for plate counting colonies of bacteria. The magnification made the fat deposits much easier to measure than if no magnification had been used.

All marbling deposits having surface areas 2 square millimeters or larger (an arbitrarily stipulated minimum) were measured with the aid of a compass and a millimeter rule. The margins of length and width of each deposit were established with the compass. The millimeter rule, secured by means of tape to the frame of the colony counter to facilitate measurement, was then used for measuring the distance between the two points of the compass. These measurements were recorded for each individual fat deposit within the rib eye sample. In order that no deposit would be missed or recorded more than once, a drop of ink was placed upon each immediately after measurement. Certain fat deposits varied in width. Where this was the case each deposit was divided into section lengths in such a way that, within each section, width uniformity was most nearly attained. All sectional fat areas coming from the same deposit were then added together and tabulated as a single fat deposit.

The remaining fat deposits, those having an area less than 2 square millimeters, were counted and the number recorded. These fat deposits added to the number of measured deposits equalled the total number of visible fat deposits in the entire rib eye muscle.

After the fat measurements had been obtained, each rib eye sample was finely ground and a 10-gm. aliquot removed from each for the purpose of determining fat by ether extraction. The aliquot was dried in an electric oven for 36 to 40 hours at 70° C., removed and then dried for 5 additional hours in a vacuum oven at the same temperature, cooled in a desiccator and weighed. The crude fat was then determined on the moisture free sample by the method described in the A.O.A.C. (1950).

Results and Discussion

Average values determined in the samples for ether extract, measured fat area and number of fat deposits are given in table 1. These values, with the exception of ether extract, are expressed in units per square inch of rib eye. Thus, it is readily possible to compare the density (number of fat deposits per square inch) and the measured fat area of one rib eye with that of another, irrespective of the difference in total lean area that may exist between them.

The density of marbling deposits in a rib eye may be quickly ascertained by noting the total number of marbling deposits per square inch of rib

TABLE 1. MEAN VALUES AND CORRELATION COEFFICIENTS FOR ETHER EXTRACT AND MEASURED AND COUNTED MARBLING DEPOSITS IN BEEF RIB EYES [a]

Item	Ether extract, %	Sq. mm. measured fat/sq. in.	No. deposits less than 2 sq. mm./sq. in.	Total no. deposits sq. in.
Mean	5.85	20.53	0.52	4.91
Correlation with ether extract		0.81**	0.63**	0.82**

[a] Values obtained by averaging the measurements of two persons.
** $P<.01$.

eye muscle. However, this value does not give any indication of the coarseness or fineness of the individual deposits. This value is easily obtained by dividing the square millimeters of measured fat per square inch of rib eye by the number of marbling deposits measured (deposits>2 square millimeters) per square inch of rib eye. Referring to table 1, the calculation may be illustrated by dividing 20.53 by 4.39 (4.91 minus 0.52) giving a mean value of 4.67 square millimeters of fat surface area for each marbling deposit.

In an effort to determine the accuracy and reliability of the method used, three persons independently measured the marbling deposits of each rib eye sample. The correlation coefficient range among individuals was found to be +0.80 to +0.93. The fat measurements between individuals had a standard deviation which ranged from 0.81 mm to 0.84 mm per square inch of eye muscle—a coefficient of variation of about 4%.

It was considered important to determine if a more accurate estimate of marbling could be obtained by measuring the marbling deposits of both sides versus one side of the rib eye sample. These results, in which two individuals measured the fat, are summarized in table 2. It may be observed from the table that the measured fat area as determined by each individual was compared to the ether extract value obtained on the same sample. While it was realized that the total fat content of a sample is not

TABLE 2. CORRELATION COEFFICIENTS BETWEEN ETHER EXTRACT AND MEASURED MARBLING DEPOSITS AND BETWEEN MEASURED VALUES FOR EACH SIDE IN BEEF RIB EYES [a]

Individuals	Correlation ether extract (%) with measured marbling			Correlation of measured marbling values [b]
	Both sides of sample	Chuck side	Loin side	Chuck side with loin side
A	0.64**	0.55**	0.49**	0.57**
B	0.69**	0.59**	0.81**	0.32 n.s.

[a] Samples were designated chuck side or loin side for the purpose of identification.
[b] Correlation of area of measured fat on one side of sample as compared to the other.
** $P<.01$.

wholly in evidence as surface marbling and that a comparison with ether extract value may not be entirely valid, nevertheless some agreement between measured fat area and total fat content was considered a reasonable assumption. This assumption is in agreement with the work of Cover *et al.* (1956). Except for the higher correlation coefficient found for the loin side measurements of individual B, an advantage in measuring both sides of the sample over one side is indicated by the values shown in table 2.

Although about 10 minutes were required to measure accurately and record the above data for each side of the sample, the additional time involved in measuring both sides resulted in a 10% to 13% increase in the accuracy of the marbling estimate when based on the total fat in the sample. The correlation found between the measured fat on one side versus the other was rather low. This is an indication of the variation that may be expected in estimating the total fat and the coarseness or fineness of marbling even when samples or cuts are obtained in close proximity to each other. Several sample sites would thus appear desirable in order to give the best estimate of marbling. Therefore, in actual practice any subjective evaluation of coarseness or fineness of marbling as it applies to the whole carcass must be made with reservations when the estimate is made at only one observation point. The angle of the cut made in relation to the grain of the meat and the somewhat random distribution of intramuscular fat deposits influence both the degree of coarseness and the amount of marbling present on a cut surface of meat. To a certain extent it is possible to control the angle of the knife cut, but the amount of intramuscular fat exposed on the cut surface is partially due to chance.

The data appear to indicate that this procedure for measuring marbling can be fairly well duplicated by different persons provided that a standard technique is adopted. Proficiency may be increased with practice. It is important that the marbling deposits be measured as soon after cutting the sample as possible. Unless this is done, due to loss of moisture, the muscle fibers shrink away from the fat deposits and a faulty measurement will be obtained. The rib eye should be moistened with a damp cloth if the surface becomes dry during measurement.

In relation to carcass studies, this method should be useful for determining the degree of marbling in meat coming from cattle in breeding, feeding or nutrition programs. Data predicting the reliability of this method in determining carcass grade will be presented elsewhere.

Summary

An objective method for estimating the amount and degree of fineness of marbling in the beef rib eye muscle is described.

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DIGESTION OF STARCH AND SOME OF ITS DEGRADATION PRODUCTS BY NEWBORN PIGS [1]

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MORE information on the digestion of starch by newborn pigs is required before one can decide whether it is possible to improve its utilization with supplemental enzymes or other materials. The saliva of 1- to 4-day-old pigs is very low in amylase (Hudman *et al.*, 1957). Pancreatic amylase, while also negligible at birth, rises rapidly during the first 3 to 5 weeks (Kitts *et al.*, 1956; Hudman *et al.*, 1957). Undamaged starch granules are digested very slowly *in vitro* by most amylase preparations (about 2% digestion in 30 minutes) and only become readily digestible if they are ruptured mechanically or treated with heat or various chemicals until they lose their bifringence (Newton *et al.*, 1940; Sumner and Myrback, 1951).

The amylotic hydrolysis of starch results mostly in maltose with small quantities of glucose and some oligosaccharides (Larner and McNickle, 1955). Bailey *et al* (1956) reported that the intestinal maltase activity of the baby pig was negligible at birth but increased rapidly during the following 25 days. Cunningham and Brisson (1957) found that maltose disappeared from ligated small intestines of pigs at birth at the rate of 0.66 gm. per kg. of body weight per hour and that orally ingested maltose was 97.4% digested by 2- to 5-day-old pigs. Maltose must be hydrolyzed to glucose before it can be utilized (Rosenthal, 1928; Pigman, 1957) but small amounts may pass directly through the intestinal epithelium of rabbits (Larner and McNickle, 1955a). Newton and Sampson (1951) found that maltose given intravenously was effective in reviving comatose colostrum-free pigs which had been starved for 48 hours. This means that maltose absorbed unchanged by the newborn pig can be utilized.

Various methods may be used to study the ability of baby pigs to digest carbohydrates but all have their limitations. The digestive system of the pig develops so rapidly that it is difficult to appraise the digestive capacity at any specific time with the conventional feeding and digestion trial technique. The assay of secretory tissues for enzymes may be used for comparative purposes but since it shows only the enzyme present in the tissue at a particular time, it is not an accurate measure of the total digestive capacity. The administration of carbohydrates by stomach tube and the measurement of undigested material later remaining in the digestive tract (Cori, 1925) is quite useful but it is difficult to compare the

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rate of intestinal digestion of soluble and solid carbohydrates which may pass through the stomach at different rates. Intestinal loop studies are subject to variations due to the effect of anesthesia and manipulation of the intestines during the operative procedure but are useful in testing the effectiveness of enzymes which would be destroyed upon passing through the stomach. Administration of carbohydrates by stomach tube and measurement of the resultant rise and fall in blood sugar has recently been used with calves (Dollar and Porter, 1957). Repeated observations can be made on the same animal but it is difficult to interpret the resultant blood sugar curve with respect to the total carbohydrate digested.

Each of the above methods has its merits but since the information obtained with any one method is limited, several procedures were employed in the present work to study the mechanisms involved in the digestion of starch by newborn pigs.

Experimental

Materials. Raw corn starch, soluble starch, maltose and glucose were used in the following experiments. The soluble starch was prepared by mixing raw corn starch in a Hobart mixer with 33% by weight of 0.15N HCl. It was spread 1/8 inch thick on flat trays and heated at 150° C. in a forced air oven until the starch granules lost their bifringence when observed with polarized light (usually 15 to 20 minutes). This preparation was readily soluble in cold water, contained approximately 15% by weight of reducing substances (calculated as maltose) but still showed a blue color reaction with iodine. Treatment with 2% of its weight with pancreatic amylase [3] for 2 hours resulted in the release of a further 40% of its weight of reducing substances calculated as maltose. Reagent grade maltose and glucose were used in all tests except in the feeding trial where technical grade maltose and commercial cerelose were used.

Comparison of Raw Starch, Soluble Starch, Maltose and Glucose by Standard Feeding and Digestion Trial Technique. Twenty, 2-day-old Yorkshire pigs were allotted according to litter and body weight to four comparable groups. They were individually penned in wire-floored cages equipped for the separate collection of urine and feces. Room temperature was thermostatically controlled at 80° F. for the first 5 days and at 70° F. thereafter. Preparation of the purified basal diet shown in table 1 was similar to that reported previously (Cunningham and Loosli, 1954). Each group received the basal diet with one of the above carbohydrates. Animals were fed *ad libitum* between 7 a.m. and 8 p.m. with feed restricted only if diarrhea occurred. Fecal collections began when the pigs were 3 days old and ran for two successive periods of 7 and 13 days.

Digestibility and growth data are presented in table 2. The glucose,

[3] Pancreatic amylase—Diastase (animal) 1–50–5 minutes. Nutritional Biochemicals Corp., Cleveland, Ohio.

TABLE 1. COMPOSITION OF T[illegible] E BASAL DIET FED IN EXPERIMENT 1

Ingredient	Gm./kg. of fluid diet
Crude casein	40.0
Carbohydrate	50.0
Lard [a]	28.0
Lecithin	2.0
Minerals [b]	9.9
Vitamins [c]	
Antibiotic [d]	

[a] The lard was homogenized with lec[illegible]hin before being added to the diet.

[b] Minerals in gm. per kg. of diet [illegible]Ca(OH)$_2$ 1.0; KOH, 0.959; NaOH, 0.928; $CaCl_2$, 1.565; $CaCO_3$, 0.140; Conc. HCl, 0.101; [illegible]$O_4 \cdot 7H_2O$, 0.050; $CuSo_4 \cdot 5H_2O$, 0.004; $CoCl_2 \cdot 6H_20$, 0.0014; $MnSO_4 \cdot 4H_2O$, 0.0034; $ZnSO_4 \cdot 7H_2O$, [illegible].031; KI, 0.0003; MgO, 0.298; KH_2PO_4, 2.873; citric acid, 1.998.

[c] Vitamins in mg. per kg. of diet: Thiamine, 1.28; riboflavin, 1.28; niacin, 4.26; choline chloride, 200; pyridoxine HCl, 1.28; folic acid, 0.52; para-aminobenzoic acid, 1.06; calcium pantothenate, 2.13; inositol, 10.64; biotin, 0.021; B_{12}, 0.025; alpha-tocopherol, 5.0.

Vitamin D_3, 400 I.U. per kg. of diet; vitamin A palmitate, 4000 I.U. per kg.

[d] Chlortetracycline, 10 mg. per kg. of diet, was supplied by Dr. T. H. Jukes, American Cyanamid Co., Pearl River, N. Y.

TABLE 2. AVERAGE WEIGHT GAINS AND DIGESTIBILITY DATA OF PIGS FED CARBOHYDRATES IN PURIFIED DIETS

Item	Glucose	Maltose	Soluble starch	Raw starch
	Period 1 (3–10 days)			
Av. initial wt., gm.	1980	1983	1977	1979
Av. D.M. intake per day, gm.	102	94	88	81
Av. wt. gain per day, gm.	71	51	48	32
Av. digestibility				
Dry matter	97.3	95.8	95.6	97.6
Fat	94.2	94.8	95.4	96.5
Protein	97.8	93.9	94.4	97.8
Ash	95.1	92.6	94.1	94.8
CHO	99.2	98.1	97.0	98.7
CHO dig. per kg./hr.	0.72	0.72	0.68	0.60
Av. days of scours per pig	0.4	0.6	0.4	0.2
	Period 2 (10–23 days)			
Av. D.M. intake per day, gm.	167	168	162	162
Av. wt. gain per day, gm.	162	166	160	158
Av. digestibility				
Dry matter	96.5	95.9	95.4	96.3
Fat	92.4	90.6	92.7	93.5
Protein	97.4	95.8	94.8	96.9
Ash	93.1	92.2	93.1	91.9
CHO	98.9	99.6	97.9	98.9
CHO dig. per kg./hr.	0.75	0.79	0.79	0.81
Av. days of scours per pig	1.60	1.00	0.60	0.40

maltose and soluble starch diets were consumed readily by 2-day-old pigs but several pigs fed raw starch were slow in accepting their diet. The average daily dry matter intake of the raw starch group was lower during the first 7 days than that of the other groups but the differences did not reach statistical significance. The average daily weight gain of the raw starch group was significantly lower ($P<0.05$) than that of the glucose group during the first 7 days but not during the remainder of the experiment.

TABLE 3. EFFECT OF AMYLASE AND INTESTINAL DIGESTION OF RAW AND SOLUBLE STARCH BY BABY PIGS [a]

	Raw starch				Soluble starch			
Replicate	0 days	5 days	10 days	15 days	0 days	5 days	10 days	15 days
	Total starch injected per pig							
	1.84	4.60	6.90	9.20	1.97	4.93	7.39	9.86
	Rate of digestion (gm./kg. body wt./hr.)							
	Controls							
Rep. 1	0.10	0.47	0.54	0.50	0.37	0.44	0.81	0.65
Rep. 2	0.07	0.35	0.38	0.71	0.47	0.71	0.56	0.61
Av.	0.08	0.41	0.46	0.60	0.42	0.57	0.68	0.63
	Amylase [b]							
Rep. 1	—.02	0.27	....	0.42	0.42	0.88	1.13	....
Rep. 2	0.15	0.58	0.29	0.45	0.50	0.64	0.51	1.02
Av.	0.06	0.42	0.29	0.43	0.46	0.76	0.82	1.02

[a] Two additional pigs, one at birth and the other at 10 days were used to determine the reducing substances normally extracted from the intestine by the washing procedure. The factor equivalent to 0.13 gm. of starch per kg. of body weight was subtracted from the starch recovered from the intestine of each pig.

[b] Missing values are due to the loss of two pigs while still with the sow.

There was no significant difference in the digestibility of any of the components of the diets during either period. A lower incidence of diarrhea was recorded for pigs fed starch during both periods. Even though the feed consumption of the raw starch group was lower during the first period, the digestibility of the raw starch, as observed in earlier work (Cunningham and Brisson, 1957a), was over 98%. It is interesting to note that while newborn lambs (Cunningham, 1956, unpublished data) and calves (Shaw *et al.*, 1918) will consume more starch than they can digest, recording low digestion coefficients, the newborn pigs in these experiments appeared to restrict their intake of starch-containing diets to the quantity of starch they could digest.

Effect of Amylase on the Digestion of Raw and Soluble Starch in Intestinal Loops. Thirty-two pigs were used. Litter mates were removed from sows in groups of four at 5-day intervals from birth to 15 days of age. Pigs were starved for 16 hours prior to the intestinal loop operation

(Cunningham and Brisson, 1957); they were anaesthetized lightly with ether, a laparotomy performed and the small intestine ligated at both ends. Each pig received one of the following treatments; raw starch, soluble starch, raw starch plus 1% of its weight as pancreatic amylase, and soluble starch plus 1% amylase. Levels of 2.0, 5.0, 7.5 and 10.0 gm. of air-dry starch were used with 20-hour, 5-day, 10-day, and 15-day-old pigs, respectively. The starch was mixed in water at the rate of 10 gm. per 100 ml., warmed to 37° C. and injected into the intestine within one inch of the pylorus. Pancreatic amylase was not added to the mixture until just before injection. The incision was quickly sutured and exactly 2 hours after the starch was injected, the pig was killed by severing the blood vessels of the throat. The intestine was removed, washed out with distilled water and the undigested starch determined by a procedure similar to that used for maltose (Cunningham and Brisson, 1957).

Little or no raw starch was removed from the intestine of the baby pig at 20 hours but the rate of digestion was significantly higher ($P<0.01$) at 5 days of age. Comparatively large quantities of soluble starch were digested at 20 hours with the rate of digestion during the first 5 days significantly higher ($P<0.01$) than that of the raw starch. The rate of digestion of soluble starch appeared to increase with age but with values missing due to the deaths of two older pigs, this can only be regarded as a trend. Pancreatic amylase did not improve the rate of digestion of raw starch at any time up to 15 days of age. The enzyme appeared to result in an increase in the rate of digestion of soluble starch, particularly in the 10- to 15-day-old pigs but the differences were not statistically significant.

Failure of the supplemental amylase to improve the digestion of starch was not the result of its destruction in the intestine. This was checked by injecting 10-mg. quantities of the preparation into 30-inch loops of the small intestine of two 11-day-old pigs and recovering the amylase 2 hours later. Over 75% of the injected amylase (including amylase originally present in the intestine) was recovered in both cases. The amylase recovered from an adjacent loop of the intestine in which no amylase had been injected had less than 10% of the activity of the injected preparation. Fifty mg. of pancreatic amylase was completely inactivated when placed in the stomach for 2 hours or treated with HCl solution at pH 3 for 10 minutes. There was 50% inactivation at pH 4 for 10 minutes and 77% at pH 4 for 30 minutes.

Comparison of Digestibility of Carbohydrates Using Carbohydrate Tolerance Curves. The procedure was similar to that used by Dollar and Porter (1957) with calves. Two-day-old pigs were raised on skim milk powder supplemented with vitamins A, D and trace minerals. At intervals, four litter-mates were starved overnight, weighed, and one of the four test carbohydrates administered by stomach tube. One group of four pigs was used on the 3rd, 10th and 21st days, a second group from the same

litter on the 7th, 14th and 28th days and a third group from another litter on the 42nd day. The drench contained 10 gm. of carbohydrate per kg. of body weight but the level was adjusted according to the age of the pig to yield a reasonably high blood sugar curve and yet approximate the carbohydrate usually consumed in 4 hours by pigs in the feeding trial.

Blood samples were taken from the tails of the pigs just before the carbohydrates were administered and at 0.5, 1, 1.5, 2, 3 and 4 hours later. Duplicate 0.2-ml. samples were analyzed for reducing sugars (Somogyi, 1926).

The carbohydrate tolerance curves of the pigs at several ages are shown in figure 1. An estimate of the digestibility of the carbohydrates may be obtained by comparing the total rise in blood sugar and the time required for the blood sugar to return to normal levels. Glucose was rapidly digested by pigs at all ages. The rate of digestion of maltose did not begin to approach that of glucose until the pigs were 7 days old. The rate of digestion of soluble starch showed a marked improvement when the pigs reached 10 days of age but it was always lower than that of maltose. The rate of digestion of raw starch was close to that of soluble starch in 3- to 7-day-old pigs but was lower in 10- to 42-day-old pigs. One of the main differences in the tolerance curves of the two starches was that the blood glucose declined to normal levels within 4 hours at 10 days of age in pigs given soluble starch but not until 42 days of age in pigs given raw starch. Link (1954) reported that the renal threshold level of 3- to 53-kg. pigs ranged from 142 to 169 mg. per 100 ml. of blood. The blood glucose curves in figure 1 often exceeded these levels by a large margin and it appeared that there might have been some loss of carbohydrate in the urine. This was checked by treating eight, 4-week old pigs in a manner identical to those in the above trial. The pigs were starved 16 hours, divided into groups of two and each group received one of the test carbohydrates by drench at a level of 6.5 gm. per kg. of body weight. The total sugar (Benedicts method, Hawk *et al.*, 1947) excreted in the urine during the first 4 hours averaged 2.54, 0.42, 0.23, and 0.00 gm. for the glucose, maltose, soluble starch and raw starch groups, respectively. The highest concentrations appeared in the first samples obtained within 69 to 125 minutes after drenching and contained 2.44, 0.59, 0.40 and 0.00% sugar, respectively. No reducing substances were detected in the urine of any of the pigs after 4 hours.

An additional 40 urine samples were obtained from the pigs fed purified diets during the second week of the feeding trial. Uncontaminated samples were obtained by placing clean screens and urine funnels in the cages approximately 1.5 hours after various feedings throughout the day. No reducing sugars were found in the urine of any pigs fed soluble or raw starch but 6 out of 10 samples from pigs fed glucose contained 0.10 to 2.41% (av. 0.62%) reducing sugars and 9 out of 10 samples from pigs

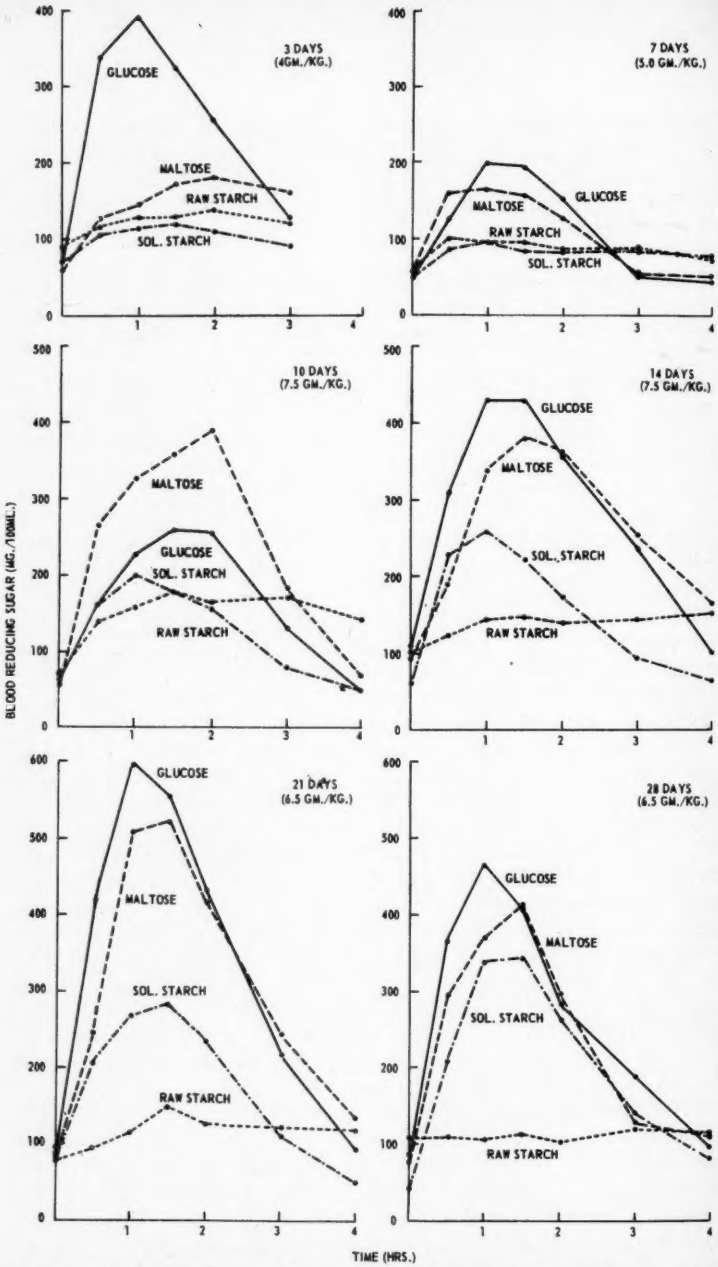

Figure 1. Carbohydrate tolerance curves of pigs given carbohydrates by stomach tube. The dosage level of carbohydrate is given under the age of each group.

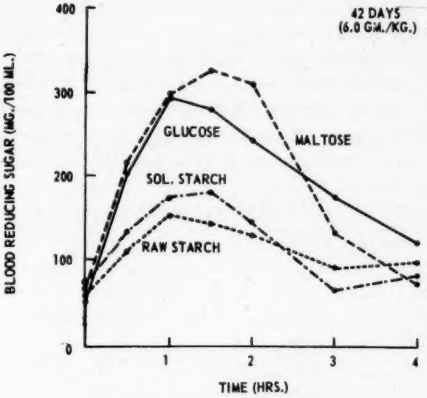

Figure 1. Continued.

fed maltose contained 0.06 to 0.48% (av. 0.22%) sugar. The carbohydrate consumed per feeding varied from 2.8 to 6.5 gm. per kg. of body weight and the highest urine sugar values were recorded at the highest levels of sugar intake.

Rate of Digestion of Carbohydrates Given by Stomach Tube. Four litter mates were removed from the sow before suckling. Each received a drench containing 10 gm. per 100 ml. of one of the test carbohydrates administered at the rate of 65 ml. per kg. of body weight. Two other groups of four litter mates, one at 14 days and one at 21 days of age were starved 16 hours and treated similarly. One additional 24-day-old pig was treated with raw starch. Exactly 4 hours after dosing the pigs were killed; the stomach, small intestine and large intestine (including caecum) were ligated, washed out with distilled water and the contents analyzed for carbohydrates.

Table 4 shows that in all pigs drenched with glucose and maltose, most of the sugar had been removed from the gastrointestinal tract within 4 hours. The glucose was more completely digested than the maltose but since the digestion coefficients were high, the rates of digestion given as gm. per kg. of body weight per hour, probably represent minimum rather than maximum values. Only small quantities of soluble starch were found in the gastrointestinal tract with a maximum of 36% recovered in the 15-day-old pig. Raw starch was slowly digested in comparison to soluble starch with large quantities found in the stomach and small intestine. A comparatively large portion of the starch remained in the stomach at 20 hours of age and may have retarded the rate of digestion somewhat but this should not have been the case at 15 days of age when slightly more soluble starch was found in this organ. The rate of digestion of

raw starch improved from 0.35 gm. per kg. per hour at 20 hours to 0.68 gm. at 25 days of age but there was little change in the rate of digestion of the soluble starch with age. The rates of digestion of both starches compare favorably with those observed in intestinal loop studies at 15 days of age but are considerably higher at 20 hours.

The stomach capacity of several pigs, checked *post mortem* by inflation with water, varied from 48 to 53 ml. per kg. of body weight at birth

TABLE 4. RECOVERY OF CARBOHYDRATES GIVEN BY STOMACH TUBE

Age	Body wt., gm.	CHO	Percent of oral dose recovered in[a]			Dig., %	Gm. dig./kg./hr.
			Stomach	Small intestine	Large intestine		
Birth	795	Glucose	6.6	1.6	5.2	87	1.41
	825	Maltose	1.9	8.2	4.3	86	1.39
	950	Sol. st.	2.6	10.5	4.0	83	1.08
	1210	Raw st.	42.8	28.9	3.2	25	0.35
15 days	3610	Glucose	0.5	0.2	2.6	97	1.60
	3685	Maltose	4.2	1.4	10.3	84	1.37
	3350	Sol. st.	15.5	12.4	7.9	64	0.96
	3490	Raw st.	8.3	40.3	19.3	32	0.44
24 days	5900	Raw st.	24.9	27.3	1.9	46	0.65
25 days[b]	5000	Glucose		2.2		98	1.59
	4775	Maltose		11.4		89	1.45
	5350	Sol. st.		23.9		76	1.14
	4700	Raw st.		51.6		48	0.68

[a] The carbohydrates remaining in the stomach and small intestine were determined by the same method used with intestinal loops while the washings from the large intestine were analyzed for dry matter, fat, protein and ash with the undigested carbohydrates estimated by "difference".

[b] These pigs were used before the decision had been made to divide the gastrointestinal tract into three portions. The undigested carbohydrates in the pooled contents were estimated by "difference".

and from 40 to 46 ml. per kg. at 15 days. Since the drench was administered at the rate of 65 ml. per kg., some carbohydrate must have passed immediately into the small intestine at the time of drenching and was available for digestion.

Discussion

Earlier studies (Cunningham and Brisson, 1957a) indicated that the oral administration of amylases did not improve the utilization of raw corn starch. It was postulated either that the amylases were destroyed before they reached the intestine or that the starch required further treatment with enzymes or other materials for its complete breakdown to glucose. The present work shows that pancreatic amylase was not only destroyed in the stomach but if it had reached the intestine it would

have served no value in the digestion of raw starch. Additional *in vitro* studies indicated that the pancreatic amylase preparation was extremely slow in hydrolyzing raw starch but rapidly hydrolyzed soluble starch. Failure of the amylase to increase the rate of digestion of the soluble starch in the ligated intestine of the 20-hour and 5-day-old pigs might be explained by the observation that the rate of digestion of soluble starch was already approaching the rate of digestion of maltose and that the enzyme maltase might be the limiting factor. Soluble starch was digested in intestinal loops at a rate just below that of maltose according to Cunningham and Brisson (1957). The rate of digestion of soluble starch in present studies was close to that of maltose. The fact that newborn pigs digested soluble starch faster than raw starch and that supplemental amylase did not increase the rate of digestion of raw starch, indicates that the digestion of raw starch is not primarily limited by a deficiency of amylase. The actual factors required for the initial rupture of the raw starch granule must await further investigation.

Each experiment indicated that during the first week of age, glucose, maltose, soluble starch and raw starch were best utilized in this order. There were no differences in the rate of gain or feed efficiency of pigs fed the four carbohydrates during the second and third weeks of the feeding trial but there were still differences in the rate of digestion during this period in the other experiments. The rate of digestion of the soluble carbohydrates during the 4-hour period following drenching (Cori technique) was considerably higher than that recorded in the feeding trial or in the intestinal loop studies. There was, however, little difference in the rate of digestion of raw starch in the three experiments. The administration of carbohydrates by stomach tube insures that the intestine is continually being refilled but the feeding of carbohydrates with other materials during part of each day, or their injection into the intestine, may not necessarily utilize the full digestive capacity of the intestine.

A disadvantage of feeding rapidly digested carbohydrates is that the blood glucose may exceed the renal threshold. Although the sugar loss never exceeded 9% of the oral dose in the present work, consideration should be given to the relation this might have to caloric requirements or to possible deleterious physiological effects.

The slow rate of digestion of the raw starch may limit digestible energy intake but the consumption of large quantities of sugars result in hypertonic conditions in the intestinal lumen which may cause diarrhea. In studies with both the intestinal loop and Cori technique raw starch was usually found as a pasty mass in the intestine with intestinal fluid noticeably absent. Considerable fluid was usually found in the intestines of pigs given the soluble carbohydrates. The hypertonic effect of glucose was readily demonstrated by drenching a 3-day-old pig with an excess of glucose at the rate of 50 ml. of 50% solution per kg. of body weight.

The pig attempted to vomit, shivered continuously, its stomach and abdomen became noticeably distended and within 30 minutes it began to scour. Within 45 minutes it excreted a large volume of watery feces which contained a high percentage of sugar.

It was interesting to find that the soluble starch in these experiments was well utilized in comparison to the raw starch while the gelatinized starch fed in previous work was inferior to raw starch (Cunningham and Brisson, 1957a). The soluble starch was already partially degraded to dextrins and maltose which may have been more easily digested than gelatinized starch. Nevertheless, when dextrinized starch [4] was fed in a preliminary experiment, the pigs developed persistent diarrhea and did not grow as rapidly as controls fed raw starch. The effects of feeding degradation products of raw starch are obviously quite unpredictable and it is apparent that further work is needed on methods of treating starch to improve its utilization by newborn pigs.

Summary

The capacity of newborn pigs to digest raw corn starch and several of its degradation products was tested by various techniques. Glucose, maltose, and a soluble starch preparation were digested more rapidly than raw starch. The rate of digestion of raw starch introduced directly into the intestine was not improved with supplemental pancreatic amylase. The data suggest that the prime factor restricting the digestion of raw starch by newborn pigs is that responsible for the initial rupture of the starch granule. The rate of digestion of soluble starch is just below that of maltose and it is difficult to determine if the rate of digestion of soluble starch is limited by the availability of amylase or maltase. The rate of digestion of soluble starch, maltose and glucose by newborn pigs would appear to be sufficiently high to meet a large proportion of the pig's energy requirements, although consumption of such quantities of these carbohydrates may result in diarrhea.

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INFLUENCE OF THE METHOD OF PREPARATION ON THE FEEDING VALUE OF ALFALFA HAY [1]

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RESEARCH at the Illinois and California Stations (Esplin *et al.*, 1957; Meyer *et al.*, 1959) demonstrated that improved performance of lambs fed a pelleted, finely ground ration was due to increased feed intake. Further work (Meyer *et al.*, 1959) suggested that an increased rate of digestion of pelleted, finely ground hay was the basic reason for the increased feed consumption. Earlier Blaxter *et al.* (1956) showed an increased rate of feed passage when hay was finely ground and pelleted.

Meyer *et al.* (1959) noted that the grinding of hay to a fine state was probably involved in the increased rate of digestion of pelleted alfalfa hay, hence, a faster rate of feed passage through the digestive tract resulting in an increased feed consumption. This experiment was designed to study the hypothesis that the fine grinding of hay was a major factor in increased feed intake from pellets and that the pelleting process played a role by making a finely ground hay more palatable.

Materials and Methods

Hay harvested from a very uniform cutting of one alfalfa field was selected and used in a factorially designed experiment. One-half of the hay was ground through a 1/16-inch screen while the other half was a coarsely chopped hay (1-inch screen). Four identical treatments were designed for each batch of hay—the finely ground and the coarsely chopped hay. The treatments were: (1) fed as finely ground or chopped hay, (2) fed as a pellet, (3) fed as ground or chopped hay mixed with water and (4) fed as the reground pellet mixed with water. The pellet for the ground hay was a 3/8-inch pellet made in a conventional pellet mill while the coarse hay pellet was a 4-inch pellet (commonly called a wafer) made from the baled hay in a plunger-type mill. Water was mixed with the water-treated hays just before each feeding until the hays were moist but not beyond the water-absorbing capacity of the hays. More water was always absorbed by the reground hays. The pelleted, finely ground hay was reground through a 1/16-inch screen and the reground wafer resulted from grinding the wafers through a one-inch screen.

A uniform lot of 48 sheep was randomly assigned to eight lots of six lambs each. All lambs were individually fed twice daily all the feed they

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would consume. It took 2 weeks to adjust all the lambs to the feed, particularly the lambs fed the ground 1/16-inch, screen-ground meal. Therefore, the initial weights were not taken until the lambs had been eating the experimental rations for 2 weeks. All weights were taken after a 24-hour fast from feed and 12 hours without water. A sample of the feed was taken before feeding for dry matter determinations and the samples composited at the end of the trial for crude fiber, lignin and nitrogen analyses.

The lignin was determined by the method of Ellis *et al.* (1946), while crude fiber, protein and ash were determined by standard A.O.A.C. (1955) procedures. Density on the feeds was determined by weighing the amount of material which could be compacted by tapping into a

TABLE 1. CHARACTERISTICS OF THE HAYS FED[a]

Items	Finely ground			Chopped		
	Ground	Pellet	Reground pellet	Chopped	Pellet	Reground pellet
Ash, %	11.2	11.6	11.6	11.4	10.6	....
Crude protein, %	21.2	21.3	21.3	20.3	20.0	....
Crude fiber, %	26.2	24.9	....	26.4	27.1	....
Lignin, %	7.3	7.3	7.1	7.8	7.3	....
Density, lb. per cu. ft.	21.1	43.4[b]	23.0	9.2	16.0[b]	13.3

[a] Dry matter basis.
[b] Actual densities of the individual pellets were 63.7 and 24.4 lb. per cu. ft. for the finely ground and chopped hay pellets respectively.

known volume. Analyses of variance and covariance were the statistical procedures used.

Results

The various methods of preparing the alfalfa hay for feeding did not appreciably influence the composition of the hay (table 1). Pelleting approximately doubled the density of the finely ground or the chopped hay; the pelleted, finely ground hay was by far the least bulky as evidenced by a density of 43.4 lb. per cu. ft. compared to 16 lb. per cu. ft. for the pelleted chopped hay.

Figure 1 illustrates the differences in particle size. Great differences existed between the chopped and ground hays. The chopped hay and reground wafer were about the same in particle size. However, the reground pelleted, finely ground hay contained a few more larger particles than the original ground hay. This was due to fine particles that adhered together which were not separated in the regrinding process. There were, however, just as many extremely fine particles.

The gains and feed consumption of the lambs fed the finely ground hays were greater ($P<.05$) than for the lambs fed the chopped hays.

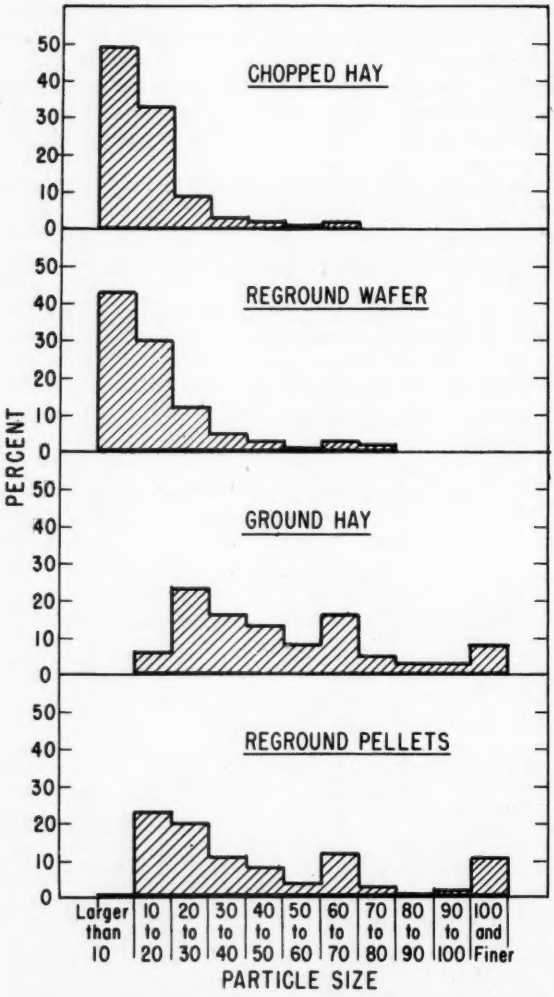

Figure 1. Comparison of the particle size of the various hays. The particle size measurements were made with sieves of the standard screen scale and the figure given is the percent of the material retained on a screen.

TABLE 2. EFFECT OF VARIOUS METHODS OF PREPARING ALFALFA ON ANIMAL RESPONSE

	Finely ground					Chopped				
Item	Ground	Pellet	Ground plus water	Reground pellets plus water	Mean	Chopped	Pellet	Chopped plus water	Reground pellets plus water	Mean
Lot number	1	2	3	4		5	6	7	8	
No. of lambs	6	6	6	6	24	6	6	6	6	24
Initial wt., lb.	75	76	74	75	75	75	75	74	77	75
Daily gains, lb.	0.20[a]	0.38	0.31	0.35	0.31[c]	0.24	0.30	0.19[b]	0.30	0.26
Daily feed consumed, lb.[d]	2.03[a]	3.59	3.17	3.12	2.98[c]	2.80	2.86	2.54[b]	2.98	2.80
Gain/100 lb. feed, lb.[d]	10.0	10.6	9.7	11.1	10.4	8.6	10.5	7.5	10.0	9.2
Carcass data:										
Dressing %	46.0	48.8	46.4	49.8	47.7[c]	45.8	44.1	46.7	46.1	45.7
Fat content, %	26.4	26.3	29.1	27.4	27.3	30.1	28.4	29.0	26.7	28.5
Slaughter grade:										
No. choice		4	1		5	1			1	2
No. good	2	2	5	5	14	3	5	4	3	15
No. utility	2			1	3	2	1	2	2	7
No. cull	2				2					

[a] A statistically significant difference at the 0.01% level between lot 1 and 2, 3 or 4.
[b] A statistically significant difference at the 0.05% level between lot 7 and lots 6 or 8.
[c] A statistically significant difference at the 0.05% level between the finely ground and chopped hay treatment.
[d] Dry matter basis.

Pelleting or adding water to the finely ground hay increased feed consumption and daily gains (table 2). This increase was statistically highly significant. While gains and feed consumption were somewhat lower for the lot receiving the ground hay plus water than for the lot fed pelleted hay, the differences were not statistically significant. Trouble was experienced in keeping the moistened hay from becoming sour. Even though care was exercised in preventing this, some influence on feed consumption probably existed.

Regrinding the pellets and mixing with water did not increase gains of the lambs fed this material when compared to those fed the finely ground hay plus water. This occurred even though there was a slight difference in density.

The response of the lambs fed the chopped hay, large pellet or wafer and the reground wafer plus water was not statistically different. Feed consumption was practically identical. For some inexplainable reason feed consumption and gains were much lower for the lambs fed the chopped hay plus water.

The analysis of covariance of weight gains adjusted to equal feed consumption in contrast to the analysis of variance of weight gains showed no difference between any treatments. This indicated that the differences in weight gains were due to feed consumption which confirms the equalized feeding done by Esplin *et al.* (1957) and Meyer *et al.* (1959) where animals fed pelleted hay and chopped hay made equal gains.

The dressing percent of the lambs fed the finely ground roughage was significantly higher than for the lambs fed the coarser roughage. Fat content of the carcasses and slaughter grade did not indicate a difference between the lambs fed the fine and coarse roughage. There were some very poor lamb carcasses from the group fed the dry finely ground hay. This may have resulted from the difficulty found in getting this group on feed during the preliminary period.

Discussion. These data add some evidence for the suggestion that fine grinding may be the major factor for the increased feed consumption of pellets and that pelleting serves to put a dusty feed in a palatable form. The evidence is: (1) the sheep fed the finely ground material had the largest feed intake, (2) adding water to the finely ground material resulted in feed consumption practically as great as from pelleting the material, (3) feed consumption did not increase as markedly when coarse material was pelleted as when the fine material was pelleted.

It seems logical to expect a larger intake of finely ground hay if the adverse influence of the dusty nature could be overcome. Meyer *et al.* (1959) demonstrated that a faster rate of digestion occurred when pelleted, finely ground hay was fed in comparison to chopped hay. Both the rate of fatty acid production and holocellulose breakdown increased when the hay was ground and pelleted. It was suggested that the fineness of grind might logically have a greater influence than bulk since grinding would

allow more entry points for bacterial enzymes. Figure 1 adequately demonstrates the differences in particle size between the chopped and ground material.

Pelleting the fine hay resulted in a feed intake increase from 2.03 to 3.59 lb. per day. Adding water to the ground hay increased the intake to 3.17 lb. per day. While this was not quite as great as for the pelleted hay, it certainly does indicate a sizeable improvement. As mentioned earlier, the rapid spoiling of the wet hay might have tempered the result somewhat. Certainly it can be stated that much of the influence of pelleting can be also obtained with wetting the ground hay.

Feed intake was not greatly increased when the coarse hay was pelleted. Gains were increased but not to a statistically significant extent. Furthermore, water additions did not greatly improve feed intake. Therefore, it appears that the greatest benefit results when a fine material is pelleted or moistened with water.

It should be emphasized that these suggestions apply to a complete roughage diet and the influence of pelleting will not be the same when concentrate is fed. Weir *et al.* (1959) report that adding concentrates to a finely ground pellet completely reversed the influence of pelleting on feed consumption. Here, feed intake was lower with a pelleted 60% concentrate ration than with the milled ration. Consequently, it appears that the best use of a pelleted, finely ground roughage will be where roughage is less expensive on a net energy basis than concentrates because less concentrate can be fed when roughage is pelleted.

However, the large coarse pellet or wafer, while not resulting in such a large influence on feed intake, might have a definite place because of its physical characteristics. This type of study does not measure the physical handling advantages but only its feeding value. Where concentrates are relatively inexpensive, the use of the wafer or pelleted, coarsely ground hay might conceivably have an economic advantage over pelleted, finely ground hay.

Aside from the main purpose of this article, little has been reported on the use of water to improve palatability of dusty ruminant rations. Dalton *et al.* (1953) reported that mixing water with concentrates increased the rate of concentrate consumption by milking dairy cows. It does appear that the use of water on finely ground feeds to increase feed consumption might have advantages under appropriate conditions.

Summary

A factorially designed experiment was conducted with growing sheep in which hay, finely ground (1/16-inch screen) and coarsely chopped (1-inch screen) was fed (1) ground or chopped, (2) pelleted, (3) ground or chopped mixed with water and (4) the reground pellets mixed with water. Feed consumption and daily gains were greater for the lambs fed the finely ground hay than for the lambs fed the coarsely chopped hay.

Pelleting the finely ground alfalfa hay resulted in increased feed consumption and increased gains. When the ground alfalfa was moistened with water, feed consumption and gains were increased to almost the same extent as by pelleting. Feed consumption and daily gains were not significantly different for lambs fed the chopped hay, the large 4-inch pellet, or wafer, or the reground wafer plus water. For some inexplainable reason water additions to the chopped hay decreased gains.

It is suggested that fine grinding is probably the major factor causing the increased feed consumption of pelleted hay and that the pelleting process serves to put a fine, dusty feed in a more palatable form.

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BLOOD SERUM PROTEIN LEVEL AS A FUNCTION OF AGE

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IN the course of investigations in this laboratory delineating fluctuations in the blood serum protein level of the bovine associated with pregnancy and parturition (Larson, 1958; Larson and Hays, 1958; Larson and Kendall, 1957), a tendency was noted for the older animals to have a higher "normal" level of protein in their serum than the younger animals. Since information could not be found in the literature indicating that such a relationship existed in the bovine or for that matter in any other species, studies were undertaken involving a significant number of dairy cattle of all ages to elaborate further on the preliminary observations.

Experimental

The University of Illinois dairy herd composed of the five major dairy breeds and Guernsey-Holstein Crossbreds was the source of the data for this study. All animals were bled during a seven-day period in August of 1956 and similarly in February of 1957. The blood was collected from the jugular vein, allowed to clot, centrifuged, and the clear serum frozen at $-18°$ C. After samples from each bleeding date had been collected, the level of nitrogen in the serum was determined by a semi-micro Kjeldahl procedure and multiplied by 6.25 to convert to protein. No correction was made for the non-protein nitrogen content. Non-protein nitrogen determinations made on several samples from cows of widely divergent ages showed no significant differences.

The number of samples, their mean values and standard errors and the mean age of the animals of each breed for each sampling date are listed in table 1. It is apparent that the mean percent of protein in the blood for all breeds is higher in the samples drawn in August than in those drawn in February. It should be noted that the average age of the animals was different at the summer and winter sampling dates. Examination of the data indicated that the percent protein in the blood increased as the age of the animal increased, thus suggesting that the means in table 1 should be adjusted for age. This was done by the method of covariance. The adjusted mean squares and degrees of freedom resulting from the analyses of covariance for all breeds are shown in table 2. The differences between sampling dates are significant for all breeds except the Guernseys. This suggests that there may be a breed by sampling date interaction, but before investigating this interaction the relationship between age and percent protein will be elucidated.

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TABLE 1. THE NUMBER OF SAMPLES (N), THE MEAN PERCENT PROTEIN IN THE BLOOD SERUM (%), THE STANDARD ERROR OF % ($\sigma_{\%}$) AND THE AVERAGE AGE (A) FOR EACH BREED AT EACH SAMPLING DATE

		Breeds						
Sampling dates	Variable	Holstein	Crossbreds (Holstein-Guernsey)	Ayrshire	Brown Swiss	Guernsey	Jersey	Total
August 1958	N	122	58	35	27	32	26	300
	%	7.06	7.15	7.17	6.97	7.17	7.01	
	$\sigma_{\%}$	0.06	0.09	0.11	0.10	0.13	0.08	
	A	2.63	2.07	2.76	3.38	3.39	3.26	
February 1957	N	113	57	34	32	26	31	293
	%	6.83	7.09	6.71	6.47	6.94	6.66	
	$\sigma_{\%}$	0.07	0.08	0.10	0.11	0.16	0.14	
	A	2.84	2.49	2.63	2.80	3.38	2.84	
All Samples	N	235	115	69	59	58	57	593
	%	6.95	7.12	6.94	6.70	7.06	6.82	
	$\sigma_{\%}$	0.04	0.06	0.08	0.08	0.10	0.09	
	A	2.73	2.28	2.70	3.07	3.38	3.03	
No. cows sampled both dates		89	49	26	19	19	20	222
Total no. different cows sampled		146	66	43	40	39	37	371

The distribution of the samples according to the age and breed of the animal is shown in table 3. Examination of the data indicated that the percent protein in the blood increased rapidly as age increased to about 4 years. The increase after this age was not in evidence. With this general relationship in mind the percent protein was fitted to a regression equation in which age (A) and the square root of age ($\sqrt{A}$) were the independent variables and percent protein was the dependent variable. An equation was derived for each breed on a within sampling date basis. The linear and curvilinear components of regression were both significant at the 1% level of probability for all breeds. The curves of the six equations were quite similar and in all cases the percent protein increased at a decreasing rate to approximately four years of age after which there was little or no change.

TABLE 2. MEAN SQUARES AND DEGREES OF FREEDOM FOR PERCENT PROTEIN IN THE BLOOD SERUM AFTER ADJUSTING FOR AGE

	Holstein		Crossbreds (Holstein-Guernsey)		Ayrshire		Brown Swiss		Guernsey		Jersey	
Source of variation	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
Between sampling dates	1	2.28**	1	1.30*	1	3.26**	1	2.72**	1	0.75	1	1.35*
Within sampling dates	232	0.33	112	0.22	66	0.27	56	0.23	55	0.37	54	0.34

* Significant at the 0.05 level of probability.
** Significant at the 0.01 level of probability.

TABLE 3. THE DISTRIBUTION OF THE SAMPLES ACCORDING TO THE AGE AND BREED OF THE ANIMAL

Breed	Age in years												
	New born	0–0.5	0.5–1	1–1.5	1.5–2	2–3	3–4	4–5	5–7	7–9	9–11	11–14	Total
Holstein	0	15	22	35	37	33	36	25	26	6	0	0	235
Crossbred	0	6	10	15	17	38	16	11	2	0	0	0	115
Ayrshire	1	3	8	7	10	17	10	4	5	4	0	0	69
Brown Swiss	0	7	4	4	7	16	6	5	5	2	3	0	59
Guernsey	1	5	2	6	6	17	4	5	5	4	2	1	58
Jersey	0	2	9	9	5	13	4	6	6	0	1	2	57
Total	2	38	55	76	82	134	76	56	49	16	6	3	593

Because of the close similarity of the curves for the individual breeds and the rather homogeneous within sampling date variances for the different breeds, the within breed and sampling date variances and covariances were pooled for all breeds. Equation 1 was derived from these pooled variances and covariances and is plotted in figure 1.

(1) $\dot{p}=4.772-0.463\pm(0.038)\ A+2.230\pm(0.130)\ \sqrt{A}.$

The tests of the linear and curvilinear components of the regression of percent protein on age are shown in table 4. Both components are significant at less than 1% level of probability. The multiple correlation obtained from predicting percent protein from age (A) and the square root of age ($\sqrt{A}$) is 0.73, indicating that the variation of the percent protein in the blood is closely associated with age.

A second equation was derived using the pooled within breed variances and covariances. This equation is plotted in figure 1 and is very similar to

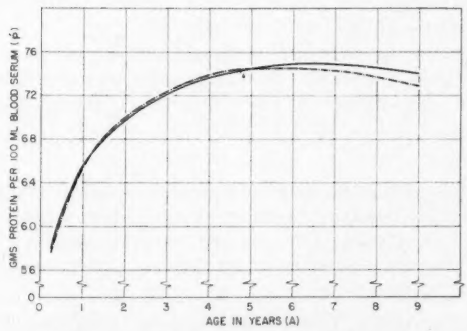

Figure 1. The relationship between mean blood serum protein level ($\dot{p}$) and age (A). a) ———— Within breeds and sampling dates. $\dot{p}=4.772-0.463A+2.230\sqrt{A}$, and b) —— — —— — Within breeds. $\dot{p}=4.958-0.383A+1.967\sqrt{A}$.

TABLE 4. WITHIN BREED AND WITHIN BREED AND SAMPLING DATE TESTS OF THE LINEAR AND CURVILINEAR COMPONENTS OF THE REGRESSION OF PERCENT BLOOD SERUM PROTEIN ON AGE

Source of variation	Within breeds		Within breeds and sampling dates	
	D.F.	M.S.	D.F.	M.S.
Multiple regression	2	63.18**	2	65.95**
Linear regression	1	76.34**	1	70.81**
Multiple—linear	1	50.02**	1	61.09**
Total—multiple	585	0.24	579	0.21

** Significant at the 0.01 level of probability.

the curve of equation 1. The difference between the curves in figure 1 is associated with variations between sampling dates. The tests of significance of the linear and curvilinear components of the regression of percent protein on age for the within breed basis are shown in table 4. Again both components are significant at less than the 1% level of probability. The linear component becomes larger and the curvilinear smaller for the within breed basis as compared to the within breed and sampling date basis.

It is apparent from the results of the analyses of covariance in table 2 that an interaction between breeds and sampling dates exists. Since the subclass numbers are disproportionate and unequal, the method of least squares as described by Henderson (1953) was used to derive the sum of squares for testing the interaction. The interaction between breeds and sampling dates is significant at the 2% level and barely misses significance at the 1% level as is shown in table 5. It is apparent that the decrease in the percent protein in the blood from the summer to the winter sampling dates differs significantly from breed to breed.

Since the interaction between breeds and sampling dates was significant, the main effects for breeds and samplings dates were tested by the method of weighted squares of means. The means for the 12 breed-sampling date subclasses were adjusted for age, using both A and $\sqrt{A}$, and then the

TABLE 5. MEAN SQUARES AND TESTS OF SIGNIFICANCE FOR BREEDS, SAMPLING DATES AND BREED x SAMPLING DATE INTERACTIONS, ALL ADJUSTED FOR A AND $\sqrt{A}$

Source	D.F.	S.S.	M.S.
Breeds[a]	5	7.81	1.56**
Sampling dates[a]	1	11.95	11.95**
Breeds x sampling dates[b]	5	3.26	0.65*
Error	579	119.58	0.21

* Significant at 0.02 level of probability.
** Significant at 0.01 level of probability.
[a] Derived by the method of weighted squares of mean.
[b] Derived by the method of least squares.

method of weighted squares of means as described by Snedecor (1956) was used to derive the mean squares for breeds and sampling dates shown in table 5. The error mean square is the same as that in table 4 for within breeds and sampling dates. It is apparent from table 5 that the differences associated with breeds and sampling dates are significant. Although these

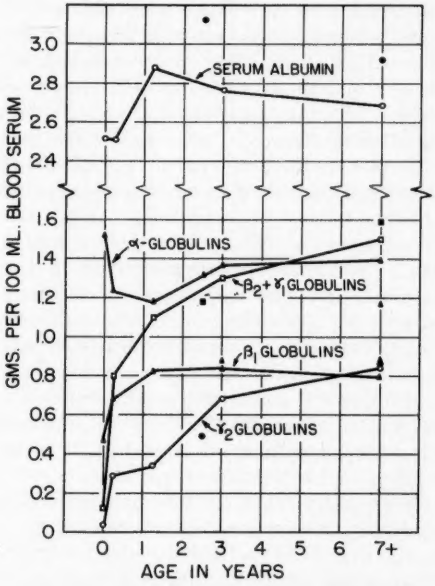

Figure 2. The specific protein composition of blood serum pooled from bovines of different ages. Open symbols are heifers and cows and the corresponding closed symbols are for bulls.

differences and their interaction are significant, it is apparent that age is the most important source of variation in the data.

Electrophoretic analyses were conducted on the blood serum to determine which of the serum protein components were responsible for the increased level with age. These analyses were conducted by the schlieren moving boundary procedure using veronal buffer of pH 8.6 and ionic strength of 0.1 (Larson, 1958; Larson and Kendall, 1957; Larson and Salisbury, 1954). The results are shown in figure 2. The portions of the serum samples not used for the Kjeldahl analyses were pooled for the electrophoretic analyses. The "0-year-old" sample represents serum obtained from three calves just after birth and before the ingestion of colostrum, the

"0.25-year-old" sample represents serum composited from the heifers between 1 and 183 days old, and similarly the "1.25" year serum from the heifers between 1 and 1.5 years old, the "3" year serum from 75 cows between 2.5 and 3.5 years old, and the "7+" serum from 33 cows between 6.5 and 13 years old. In addition analyses were also conducted on the serum of several bulls. The "2.5" year serum sample represents pooled serum collected from 13 bulls, 1.5 to 3.5 years old, and the "7+" year serum sample represents serum from four bulls between 7 and 13 years old.

As previously noted (Larson, 1958) there is a lack of resolution in electrophoretic analyses between some of the globulin components of pooled serum samples. Thus, the areas of the electrophoretic patterns were analyzed for (a) serum albumin, (b) total α-globulins ($\alpha_1+\alpha_2+\alpha_3$), (c) β_1-globulins, (d) β_2-plus Υ_1-globulins, and (e)Υ_2-globulins. In pooling the samples for the electrophoretic analyses no attempt was made to segregate them according to time relative to parturition.

Although there are some changes in all of the fractions relative to age, as shown in figure 2, it is apparent that the largest change is due to increases in the β_2 plus Υ_1 and the Υ_2 immune globulin fractions. Most of the large initial drop in the α-globulin content is undoubtedly due to fetuin which causes a high α-globulin region in newborn calf blood. After this there does seem to be a small increase in α-globulin content with age. It should be noted also that there is a tendency for the serum albumin content to drop with age. However, the large increase in serum protein level associated with increasing age apparently is due chiefly to the specific fractions of globulin associated with antibody activity.

Discussion. It is surprising that a correlation between age and blood serum protein level has not been previously demonstrated in some species. The previous unawareness of the decrease in serum protein level at parturition and other fluctuations associated with pregnancy probably has made this recognition difficult in the bovine and possibly in other species. Several investigators have shown that the protein level in the serum of the new-born bovine is low (4–5%) but increases when the new-born consumes the colostrum (Deutsch and Smith, 1957; Hansen and Phillips, 1947; Smith, 1948). Proteins including globulin antibodies present in the colostrum are transferred across the gut wall into the blood stream of the new-born during the first 24 hours (Deutsch and Smith, 1957; Hansen and Phillips, 1947; Smith, 1948). This passage of protein apparently does not raise the blood serum protein level to a "normal" level; the present studies indicate that the serum protein level continues to increase for several years.

It is noteworthy that other than initial changes in several of the components, the largest continuing increase in the serum protein level with age is caused by the β_2 plus Υ_1 and the Υ_2 immune globulins. It is known that exposure to antigenic agents causes the animal to respond with an increase in the immune globulin level (Gutman, 1948; Wostman and Gordon, 1958). After recovery from a disease, however, the level of specific antibodies to

the agent slowly decreases but may remain titratable in the blood for the remainder of the life time. The number of such titratable antibodies increases during the life time as the animal encounters various antigenic agents. The electrophoretic studies of Wostman and Gordon (1958) on germ-free and conventionally grown chicks illustrate the point that even when specific attacks of disease are not recognized in the conventionally grown chicks the contact with a multitude of antigenic agents causes an increased total immune globulin level in the blood serum when compared to the germ-free chicks. The degree to which this level of total immune globulins in the serum will rise in the aging adult has not been defined. It is apparent from the present data that in the bovine the level of total immune globulins continues to rise for several years. In the present study there were only 25 animals more than 7 years of age. Consequently the slight decrease in blood serum protein level after 7 years as shown in figure 1 is probably not significant.

This study suggests the possibility that other species may accumulate a greater immune globulin level in their blood with increasing age. The fact that the few bulls sampled also demonstrated the same changes in immune globulin level with age suggests that enough cows were used to negate the effect relative to parturition and the increasing level is not peculiar to the cow which periodically builds up and then loses much of her immune globulin level at succeeding parturitions (Larson, 1958; Larson and Kendall, 1957). This loss of immune globulins and other proteins by the cow at parturition has been implicated as being responsible for the severe edema which sometimes affects cows at parturition (Larson and Hays, 1958). This syndrome appears more frequently at the parturitions of first-calf heifers than at succeeding parturitions. The present data showing a rise in the total serum protein level with age explain why this might be expected. The older cow can afford to lose more serum proteins at parturition without lowering the level remaining in the blood below a critical level which may bring on the edema.

The results reported in this paper coupled with the previous observations (Larson, 1958; Larson and Hays, 1958; Larson and Kendall, 1957) that pregnancy and parturition cause fluctuations in the serum protein level, make it necessary to take these variables into consideration when studying serum protein level in the bovine. Not only does the "normal" blood serum protein level continually change under the influence of these factors but it is apparent that the ratios of the specific proteins present also change.

Summary

A highly significant positive correlation was found between age and blood serum protein level in the bovine. Several blood protein fractions associated with antibody level were responsible for the increased serum protein level with age.

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RELATIONSHIP OF LIVE ANIMAL MEASUREMENTS TO VARIOUS CARCASS MEASUREMENTS IN BEEF [1, 2]

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ONE of the major handicaps in the improvement of beef cattle carcasses is the lack of an accurate method of measuring carcass traits in live cattle. In the past, improvement has been made through visual evaluation, but prediction of carcass traits by visual appraisal of live cattle has been of low accuracy. Such live-animal measurements as weaning weight and grade, rate and efficiency of gain, weight at the end of feeding period and slaughter weight and grade have been found important items in performance studies (Black and Knapp, 1936; Knapp *et al.*, 1941 and 1942; Knapp and Clark, 1950). In addition, certain linear body measurements have been investigated to ascertain changes during growth and fattening (Lush, 1928, 1929; Johnson, 1940; Barton, 1938; Wanderstock and Salisbury, 1948; Kidwell, 1955). A number of workers (Severson and Gerlaugh, 1917; Lush, 1932; Hankins and Beard, 1944; Yao *et al.*, 1953) have reported that width, depth and circumference measurements of the live animal reflect the degree of finish in the carcass. Although a great many investigators (Lush, 1932; Hankins and Beard, 1944; Cook *et al.*, 1951; Yao *et al.*, 1953; Green, 1954; Kidwell, 1955) have found that the so-called "fleshing measurements" (width, depth and circumference) are directly related to grade and dressing percentage, only a limited amount of work (Branaman, 1940; Henneman, 1942; Ljungdahl, 1942; White and Green, 1952; Tallis *et al.*, 1957) relating carcass measurements to detailed carcass traits has been reported.

Therefore, this study was initiated in an attempt to relate live animal measurements with various carcass measurements and to ascertain their relationship to weights and percentages of wholesale cuts.

Materials and Methods

A total of 31 long yearling steers from the Michigan State University performance testing program were used in this study. The group was composed of 8 Angus and 23 Hereford steers. The steers were allowed access to water but were deprived of feed for 24 hours prior to slaughter. The average slaughter weight was 856 $\pm$ 76 lb. The slaughter procedure recommended by Deans (1951) was followed, except that the carcass was

[1] Journal Article 2379, Michigan Agricultural Experiment Station.

[2] A portion of the research reported in the Ph.D. Thesis of the senior author to the School for Advanced Graduate Studies, Michigan State University.

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[4] This study was conducted in cooperation with the North Central Regional Project NC-1, The Improvement of Beef Cattle Through Breeding Methods.

not split in order that measurements could be taken on the intact carcass. Carcasses were shrouded and chilled at approximately 35° F. for 7 days before cutting. Dressing percentages were based on 48-hour chilled carcass weights and off-feed live weights. The mean carcass yield was

TABLE 1. REPEATABILITY ESTIMATES FOR LIVE ANIMAL AND CARCASS MEASUREMENTS [a]

Measurement	Repeatability estimates	Measurement	Repeatability estimates
	Live animal measurements		
Width		Height	
Neck	0.90	Brisket to crops	0.86
Shoulder	.88	Withers	.96
Rump	.84	Rump	.96
Round	.88	Smooth joint to dew	
Pins	.50	claws (rear cannon)	.96
Hooks	.83	Smooth joint to floor	.73
Between 13th rib and hooks	.84	Break joint to dew claws	.88
13th rib	.73	Break joint to floor	.94
Between 13th rib and crops	.82	Twist to floor	.90
Crops	.72	Twist to hocks	.73
Length		Rump to hocks	.74
1st thoracic to pins (body)	0.82		
1st thoracic to 13th rib	.86	Circumference	
13th rib to hooks	.52	Fore flank	0.98
Hooks to pins (rump)	.86	Hind flank	.94
		Middle	.99
Spring of ribs	0.43	Fore legs above knee	.70
		Fore legs below knee	.80
		Hind leg above hock	.83
		Hind leg below hock	.96
	Carcass measurements [b]		
Depth of body at 5th rib	0.87	Width at round	0.98
Depth of flank	.78	Circumference of round	.98
Width of shoulder	.98	Circumference of fore shank	.95
Width at crops	.97	Body length	.99
Width at rump	.92		

[a] Required for significance, 0.50, at P=0.05, and 0.62 at P=0.01.
[b] All carcass measurements were made on the unsplit carcass.

61.8 ± 1.3%. Each carcass was graded to the nearest third of a grade by a Federal grader 72–96 hours after slaughter. Average numerical carcass grade was 19.5 ± 1.3, when high Prime = 24, high Choice = 21 and high Good = 18.

All measurements on both carcasses and live animals were taken twice the second year to check the accuracy of measurement. The live animal and carcass measurements taken are recorded in table 1. Special mention is given to the procedures for measuring spring of rib and circumference

of round on the live animal. Spring of rib was measured with a V-shaped tool having two movable arms and a horizontal leveling bulb. The shorter of the arms was placed at the middle of the back at a point adjacent to the crops and leveled while the other arm was closed until contact was made with the steer's rib. The arms were locked and the angle was traced on paper and subsequently measured with a protractor. Circumference of round was measured by encircling the hind leg with a tape at the stifle joint and holding the tape parallel to the floor while making the measurement.

The left side was cut into wholesale cuts according to the procedure of Hankins and Howe (1946) as modified by Wellington (1953). The area of the ribeye at the 12th rib was measured on the left side from a tracing with a planimeter and thickness of fat was determined at the 12th rib according to the procedure recommended by Naumann (1951). In addition, the *Psoas major* and *Semitendinosus* muscles were excised, cleaned and weighed to the nearest gram. Further details on the measureing and cutting procedures have been described by Orme (1958).

Simple and multiple correlation coefficients and standard partial regression coefficients were calculated for the data (Snedecor, 1946). All analyses were made on a within year basis to eliminate the effect of year to year variation.

Results and Discussion

Estimates of Repeatability. Independent, duplicate live-animal measurements were obtained for each steer the second year in order to acquire an estimate of repeatability for a particular measurement. The repeatability estimates were from 0.43 for angle or spring of ribs to 0.99 for circumference of middle (table 1). All estimates of repeatability were either significant or highly significant except for spring of ribs. The best repeatability estimates were obtained for the various height measurements (withers, rump and legs), circumference measurements (fore and hind flanks and middle), and various measurements of width (round, rump and shoulder).

All carcass measurements taken were highly repeatable, length of body being most repeatable and body depth measurements least. Repeatability estimates were closely related to the ease of defining the reference points.

Relationship of Live Animal and Carcass Measurements. In order to test the validity of using various live-animal measurements to estimate a particular carcass measurement, correlation coefficients were calculated (table 2). Comparable live-animal and carcass measurements were correlated when available; whereas, in other instances, the correlations between the measurements of the live animal and carcass were chosen for best fit. All width measurements of the carcass were highly correlated with the corresponding live-animal measurements. Since these estimates were all higher, except for width of crops, than similar estimates made

between subjective live-animal scores and carcass measurements, it was evident that width of carcass could be more accurately predicted from live-animal measurements than from subjective scoring (Orme, 1958). Depth measurements of the carcass could also be predicted more accurately from the objective live-animal measurements than from the subjective scores which were reported by Orme (1958). Circumference of the round on the carcass was significantly related to circumference of hind leg above the hock on the live animal. Height at the rump was found to be

TABLE 2. SIMPLE CORRELATION COEFFICIENTS BETWEEN LINEAR CARCASS AND OBJECTIVE LIVE ANIMAL MEASUREMENTS

Live animal measurement	Carcass measurement [b]	r
Width of shoulder	Width of shoulder	0.77**
Width at crops	Width at crops	.64**
Width of rump	Width of rump	.76**
Width of round	Width of round	.66**
Depth from brisket to crops	Depth of chest at 5th rib	.58**
Circumference of middle	Depth at flank	.42*
Circumference of hind flank	Depth at flank	.43*
Circumference of leg above hock	Circumference of round [a]	.51*
Circumference of leg above knee	Circumference of foreshank [a]	.39
Height at withers	Length of carcass	.33
Height at rump	Length of carcass	.80**
Length from 1st thoracic to pins	Length of carcass	.01

[a] Only 15 steers included.
[b] All carcass measurements made on unsplit carcass.
* Significance at P=0.05.
** Significance at P=0.01.

highly related to carcass length, accounting for approximately 64% of the variation.

Weight. Ribeye area and live weight were correlated with live animal measurements to determine the relationship existing between these items (table 3). Correlation coefficients of 0.51, 0.52 and 0.53 were obtained between ribeye area and circumference of body at fore flank, circumference of body at hind flank and circumference of middle, respectively. All were highly significant. Thus, the steers with the larger body circumference tended to have larger ribeyes. Other relationships between various live-animal measurements and ribeye area were significant at the 5% level. They included width of rump 0.35, circumference of hind leg above hock —.36 and 0.38 for live weight. Thus, there was a tendency for the heavier steers and those with the wider rumps to have larger ribeyes, while the steers having the larger leg circumferences above the hock tended to have the smaller ribeye area. The negative relationship between circumference of the leg above the hock and ribeye area was not expected since livestock judges use size of round on the live animal as an indicator of ribeye size.

TABLE 3. SOME SIMPLE AND MULTIPLE CORRELATION COEFFICIENTS BETWEEN LIVE ANIMAL AND CARCASS MEASUREMENTS

X	r Ribeye area with	b'[a]	R Ribeye area with live weight and	r Percent primal cuts with
Width measurements				
Crops	0.20	0.04	0.38	—.12
Between crops and 13th rib	—.05	—.14	0.40	—.13
13 rib	0.12	—.18	0.40	—.12
Between 13th rib and hooks	0.15	—.12	0.39	—.13
Pins	0.18	0.07	0.39	—.44*
Round	0.30	0.08	0.38	—.32
Rump	0.35*	0.17	0.40	—.40*
Hooks	0.23	0.04	0.38	—.14
Shoulder	0.22	—.22	0.40	—.28
Neck	—.05	—.30	0.46*	—.24
Length measurements				
1st thoracic to pins	0.07	—.21	0.42	0.31
1st thoracic to 13th rib	0.14	—.12	0.39	0.10
13th rib to hooks	0.12	0.27	0.38	0.15
Rump	0.04	—.10	0.39	0.32
Height measurements				
Withers	0.11	—.47	0.48*	—.04
Rump	0.04	—.45	0.50*	0.31
Rump to hocks	0.34	0.20	0.42	—.06
Twist to floor	0.12	—.24	0.45*	0.30
Twist to hocks	—.05	—.01	0.38	0.15
Brisket to crops	0.26	0.03	0.38	....
Circumference measurements				
Fore flank	0.51**	0.89	0.54**	—.46**
Rear flank	0.52**	0.58	0.52**	—.42*
Middle	0.53**	0.57	0.53**	—.53**
Fore leg above knee	0.04	—.11	0.39	0.07
Hind leg above hock	—.36*	—.57	0.65**	0.04
Fore cannon	—.23	—.55	0.61**	0.35*
Hind cannon	—.30	—.46	0.58**	0.41*
Weight				
Hind quarter	....	....	....	—.09
Fore quarter	....	....	....	—.32
Total	....	....	....	—.24

[a] Standard partial regression of ribeye area on X with weight held constant.
* Significance at P=0.05.
** Significance at P=0.01.

Correlation coefficients for live-animal measurements and weights were calculated with ribeye area and percent primal cuts (table 3). In each case, the relationship was found to be higher between the live-animal measurements and live weight than with ribeye area. As reported by Johnson (1940), Lush (1929), Barton (1938), Kidwell (1955) and other workers,

the circumference of body at fore flank was the best single estimate of body weight. The correlation coefficient obtained in the current study was 0.90, which accounted for 81% of the variation in weight.

Standard partial regression coefficients were calculated in order to study the relationship of various objective live-animal measurements to ribeye area, eliminating the effects of live weight (table 3). With weight held constant, circumference of body at the fore flank accounted for 81% of the variation in ribeye area. This was by far the best relationship found between the various live-animal measures and ribeye area. Thus, the partial regressions of ribeye area on circumference of body at the foreflank and live weight are 0.110 and —.005, respectively. Other live-animal measurements, which were associated with 20 to 33% of the variation in ribeye area, included circumferences of middle and circumference of body at the rear flank. Similar to the fore flank, they were directly related, while other measurements such as height at withers and rump, circumference of hind leg above hock and below hock and circumference of hind and fore cannons, all showed an inverse relationship to area of ribeye. The standard partial regression coefficient for all the live-animal measurements with ribeye area were increased over the simple correlation coefficients obtained previously between the same traits.

Table 3 also lists the multiple correlation coefficients obtained when ribeye area was correlated jointly with live-animal weight and the various live-animal measurements. The joint effects of live weight and the circumference of body at either fore flank, middle, rear flank, hind leg above hock, fore cannon and hind cannon were associated with 27 to 43% of the variation existing in ribeye area.

Relationship of Live Animal Measurements with Primal Cuts. Table 3 lists the correlation coefficients obtained between the various live-animal measurements and percent primal cuts (percent round, rib and loin on the live weight basis). Only two relationships between live-animal measurements and percent primal cuts were significant at the 1% level. These included the circumference of body at fore flank and circumference of middle, with correlations of —.46 and —.53, respectively. The majority of the correlation coefficient listed in table 3 were negative, thus showing a slight tendency for the steers having the larger live-animal measurements to have a lower percent of primal cuts.

Relationship Between Carcass Measurements and Ribeye Area, Live Weight and Percent Primal Cuts. Table 4 lists the correlation coefficients between various carcass measurements and ribeye area, live weight and percent primal cuts. Width of shoulder (r=0.54), rump (r=0.47) and round (r=0.48) showed highly significant relationships to ribeye area. In addition, depth of flank, depth at fifth rib and width of the crops were significantly related to area of ribeye. Thus, carcasses having the larger measurement tended to have the larger area of ribeye. Such carcass measures as carcass length, circumference of round and circumference of fore shank showed very little relationship of ribeye area.

TABLE 4. CORRELATION COEFFICIENTS BETWEEN VARIOUS CARCASS MEASUREMENTS AND RIBEYE AREA, LIVE WEIGHT AND PERCENT PRIMAL CUTS

X [a]	r Ribeye area with	r Live weight with	r Percent primal cuts with
Carcass length	0.02	0.66**	0.22
Depth at 5th rib	0.37	0.67**	—.32
Depth at flank	0.40*	0.36*	—.15
Width of shoulder	0.54**	0.79**	—.50**
Width of crops	0.41*	0.62**	—.40*
Width of rump	0.46**	0.66**	—.46**
Width of round	0.48**	0.80**	—.44*
Circumference of round [b]	0.09	0.44*	—.16
Circumference of fore shank [b]	—.20	0.79**	—.05

[a] Variable with weight held constant.
[b] Only 15 steers.
* Significance at P=0.05.
** Significance at P=0.01.

Correlation coefficients obtained between live weight and the various carcass measurements were all highly significant except for depth of flank and circumference of round, which were only significant at the 5% level (table 4). On the other hand, all correlation coefficients between the percent

TABLE 5. SIMPLE AND MULTIPLE CORRELATION COEFFICIENTS BETWEEN RIBEYE AREA AND PERCENT OF HIND AND FORE QUARTERS, PERCENT PRIMAL CUTS, PERCENT WHOLESALE CUTS AND PERCENT *PSOAS MAJOR* AND *SEMITENDINOSUS* MUSCLES; ALSO, STANDARD PARTIAL REGRESSION COEFFICIENTS WITH WEIGHT CONSTANT

X	r Ribeye area with	b' [a]	R X with ribeye area and live weight
Hind quarter	—.23	—.12	0.35
Fore quarter	0.23	0.12	0.35
Primal cuts	—.51**	—.47	0.51
Sirloin+Round	—.51**	—.47	0.52
Rib	0.18	0.18	0.18
Shortloin	—.17	—.14	0.18
Shortplate	0.48**	0.39	0.53
Fore shank	—.52**	—.48	0.53
Brisket	0.14	0.03	0.31
Chuck	—.08	—.02	0.15
Kidney knob	0.59**	0.66	0.61
Flank	0.34	0.33	0.34
Psoas major [b]	—.31	—.13	0.48
Semitendinosus [c]	0.40	0.38	0.40

[a] Standard partial regression coefficient with live weight held constant.
[b] 30 steers included.
[c] 15 steers included.
* Significance at P=0.05.
** Significance at P=0.01.

primal cuts and the various carcass measurements, except body length, showed an inverse relationship to percent primal cuts. Furthermore, with the exception of width of either shoulder or rump (P=0.01), crops or round (P=0.05), the carcass measurements were not significantly related to percent primal cuts (table 3).

Relationship of Ribeye Area to Percent of Various Carcass Parts. Table 5 lists the simple correlation coefficients of percent wholesale cuts and of percent *Psoas major* and *Semitendinosus* muscles with the area of ribeye. Certain of these percentages of the carcass, namely, primal cuts, sirloin plus round, and fore shank, showed highly significant negative relationships to the area of ribeye muscle. This would indicate that as the eye muscle increased in size, the percentage of these various cuts tended to decrease. This was true whether or not live weight was held constant.

Summary

The relationship between live-animal measurements with carcass attributes was investigated using the data from 31 long yearling steers. Live-animal measurements and carcass measurements were all highly repeatable with the exception of spring of ribs, the width of pins and the length from the 13th rib to hooks.

With constant live weight, circumference of body at fore flank was associated with 81% of the variation in ribeye area, while circumference of middle, rear flank, hind leg above hock and width of rump were also significantly related to ribeye area. Live-animal weights and various live-animal measurements showed high relationships to such wholesale cuts as chuck, rib, shortloin and sirloin plus round.

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DETERMINATION OF ESTROGENIC ACTIVITY IN FRESH AND DRIED FORAGE [1]

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THE occurrence of estrogenically active substances in plant materials is well established (Bradbury et al., 1954). Although several chemical (Curnow, 1954; Lyman *et al.*, 1959) and biological (Beck, 1951; Biggers *et al.*, 1954; Cheng *et al.*, 1953; Pieterse *et al.*, 1956; Pieterse *et al.*, 1956) methods for assay of these substances have been developed, there is still need for faster and more accurate procedures.

The study reported here has two purposes: to devise improved procedures for extraction of estrogenic substances from plant material in preparation for assay and to improve the procedure for bioassay of estrogenic activity in plant extracts. The bioassay uses uterine-weight response of immature mice. Since the estrogenic activity of forage is reduced by the drying process, different methods of extraction have been developed for fresh and dried forage.

Experimental

Development of the Proposed Procedure. In a technique for routine assay of large numbers of forage samples, it is desirable that the minimum amount of processing consistent with an accurate assay should be employed. For bioassays involving oral administration, incorporation of the test material directly into the ration of the experimental animal would obviously be the simplest procedure. In the initial studies in this laboratory, it was found that when the whole dried ground clover meal was directly incorporated into the mouse ration at a level of 15%, a detectable uterine response was noted (table 1). However, when the meal was added at progressively higher levels of the diet no additional increase in uterine weight resulted. Therefore, it appeared that partial purification and concentration of the estrogen source would be desirable for a proper oral assay.

In a search for the optimum conditions for preservation of samples prior to extraction, Robinson (1949) compared the storage of fresh tissue in alcohol with several methods of drying. He found that fresh samples which were stored in alcohol gave higher uterine weights than extracts of dried samples and recommended alcohol storage prior to routine assay of clover samples. More recent methods have recommended drying the sample prior

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TABLE 1. UTERINE RESPONSES OF IMMATURE MICE TO ORAL ADMINISTRATION OF LADINO CLOVER MEAL ADMIXED WITH STANDARD DIET [a]

Clover meal in diet	No. of animals	Average body weight		Average uterine weight
		Start	End	
%		gm.	gm.	mg.
0	5	9.05	10.20	8
15	5	9.19	9.12	15
20	5	9.16	9.04	14
40	5	9.24	8.91	16
60	5	9.22	7.98	16

[a] The standard mouse basal diet contained the following ingredients, in percent: Ground yellow corn meal 75, linseed oil-cake meal 10, crude casein 10, cod liver oil 3, bone meal 1.5, and sodium chloride 0.5.

to extraction (Cheng *et al.*, 1953; Pieterse *et al.*, 1956). We have found that extracts prepared directly from fresh forage appear to contain more estrogenic activity than extracts prepared from dried forage.

Because of this apparent instability of the estrogen or increased difficulty of extraction, we felt it was desirable to develop a method of extraction for fresh tissue, which involved minimum processing. Acetone was found to be an efficient solvent for extraction of the estrogenic activity from fresh plant tissue. All the activity was extracted by maceration with acetone in a mechanical disintegrator operating at high speed for 1 minute. The aqueous-acetone extract, after filtration, was concentrated to a small volume and added directly to the mouse ration. However, the water solution left after concentration to remove the acetone contains a factor which reduces the uterine response as well as some estrogenically active materials. Ether extraction of the aqueous solution removes the estrogen(s) but not the inhibitor(s). The ether extract is added to the mouse ration and the aqueous phase discarded. These results are shown in table 2.

In most methods for preparation of estrogenic concentrates from dried forages, alcohol is employed to extract the estrogens; little or no data are

TABLE 2. EFFECT ON UTERINE WEIGHT OF WATER SOLUBLES FROM AQUEOUS-ACETONE EXTRACT OF FRESH ALFALFA

Supplement fed	Average uterine weight [a]	Equivalent of meal fed
	mg.	gm./mouse
A. Basal only	9	0
B. Basal and entire aqueous-acetone extract	43	2
C. Same as B minus water solubles	24	2
D. Same as C+ether extract of water solubles	53	2
E. Basal+water solubles after ether extraction	9	2

[a] Fifteen animals per supplement.

reported on the relative efficacy of other solvents. Therefore, a comparative study of several additional organic solvents was made. Forty-gm. aliquots of ladino clover meal were Soxhlet extracted with the following solvents: Acetone, ethanol, chloroform, ethyl ether, petroleum ether, and a 2:1 mixture by volume of benzene and ethanol. With the most effective solvents, a 24-hour extraction period was required for complete removal of the estrogenic activity (table 3).

Neither chloroform nor petroleum ether extracted substances with any measurable estrogenic activity; however, both of these solvents extracted considerable amounts of solids. Ether, although more selective for the estrogens than the other solvents, extracted the estrogenic activity at a very

TABLE 3. RELATIVE EFFECTIVENESS OF ORGANIC SOLVENTS FOR EXTRACTING ESTROGENIC ACTIVITY FROM LADINO CLOVER MEAL

Solvent	No. of animals	Time of extraction (Soxhlet)		
		12 hr.	16 hr.	24 hr.
		(Average uterine weight, mg.)		
Acetone	20	51	62	78
Alcohol	20	38	63	49
Benzene-alcohol (2:1)	20	38	64	59
Chloroform	15	9	9	9
Petroleum ether	15	9	9	9
Ether	15	..	..	17
Control	20	9	9	9

slow rate. During the first 16 hours of extraction, acetone, alcohol, and the benzene-alcohol mixture were all about equally effective. The greatest uterine weight response was obtained with a 24-hour acetone extract. The 24-hour extracts with both alcohol and the alcohol-benzene mixture were less active than the comparable 16-hour extracts. This decrease in activity with time of extraction may be due to the presence of estrogen inhibitory substances, since more material was extracted in 24 hours than in 16 hours. Acetone extracted 4.5 gm. of solids from 40 gm. of meal in 24 hours, whereas alcohol extracted 8.4 gm. Beck and Braden (1951) pointed out that if the doses of an alcoholic extract of clover are increased above a certain level, the responses progressively decline. They assumed that this phenomenon was related to the crude nature of the plant extracts rather than to the assay method. We have obtained similar data with partially purified extracts. Since the acetone extract contained less total solids and elicited a greater estrogenic response than either the alcohol or the benzene-alcohol extracts, acetone was preferably employed in our laboratory.

Use of Alkali for Extraction of Estrogenic Activity. While comparing various solvents and techniques for the initial extraction of clover meal, Robinson (1949) found that higher uterine weight responses were obtained

from the extracts when 1 *N* alcoholic potassium hydroxide was used instead of alcohol. He recommended, therefore, that whole plant material or its alcohol extract be refluxed with 1 *N* alkali as a first step in obtaining the crude estrogenic extract. Subsequent modifications of Robinson's method by other workers (Beck *et al.*, 1951; Cheng *et al.*, 1953) retained the use of alkali.

Unfortunately, it was not recognized that the use of alkali in the preliminary solvent extraction of plant materials may often lead to an erroneous evaluation of estrogenic activity. If genistein and the related isoflavonoid estrogens predominate, as in subterranean and red clovers, excessively high "apparent estrogen" assays may result. It has been reported (Pieterse *et al.*, 1956) that the estrogenic activity of genistein was

TABLE 4. DECREASE IN ESTROGENIC ACTIVITY OF ALCOHOLIC EXTRACT OF LADINO CLOVER AFTER SAPONIFICATION WITH 0.5 *N* ALKALI FOR VARYING LENGTHS OF TIME

Saponification period	Average uterine weight[a]
min.	mg.
0	51
20	27
60	15
120	8
Control ration only	8

[a] Five animals per treatment.

increased more than 4-fold by treatment with a 1.5% solution of potassium hydroxide in ethanol.

On the other hand, in plants such as ladino clover in which the estrogenic activity is predominantly derived from the coumarin-like estrogen, coumestrol (Bickoff *et al.*, 1957; Bickoff *et al.*, 1958; Bickoff *et al.*, 1958), the use of alkali may lead to erroneously low or negative results. The progressive decrease in estrogenic activity of an alcoholic extract of ladino clover, after treatment with 0.5 N alcoholic potassium hydroxide solution for increasing periods of time, is shown in table 4. It is recommended that alkali *not* be employed in the initial extraction of plant material for estrogen assay.

Purification of Extracts of Plant Materials Low in Estrogenic Activity. A preliminary extraction with chloroform can remove a large amount of non-estrogenic material from dried ground forage meals prior to acetone extraction. Much higher levels of concentrate can then be fed without noticeable growth retardation or toxicity to the mice. For example, an alfalfa meal which showed the presence of coumestrol by a chromatographic procedure (Lyman *et al.*, 1959) gave no detectable uterine response when an acetone extract was fed at the level routinely employed in our laboratory for preliminary screening of a forage (the equivalent of 8 gm. of alfalfa

TABLE 5. EFFECT OF CHLOROFORM PRE-EXTRACTION OF ALFALFA MEAL ON ESTROGENIC ACTIVITY OF SUBSEQUENT ACETONE EXTRACTS

Equivalent weight of alfalfa fed per mouse	Average uterine weights, mg.[a]	
	Acetone extract	Acetone extract after chloroform pre-extraction
gm.		
0	8	8
8	13	12
16	11	15
24	8	25
32	8	33
64	6	9

[a] Ten animals per treatment.

per 10 gm. of diet per mouse). Feeding the acetone extract at higher equivalent levels still elicited no measurable uterine response and the mice lost weight during the test period. However, when alfalfa meal was first extracted with chloroform and extract discarded, the subsequent acetone extract fed at progressively higher levels gave a series of progressively larger uterine responses. Finally, at a level of 64 gm. per mouse no uterine response was obtained (table 5).

For each plant material studied, the possible presence of toxic or growth-inhibitory substances in the acetone extract should be considered and the necessity for a preliminary chloroform extraction determined.

Comparison of the Proposed Procedure with Existing Methods. A comparative study was made with a portion of the same lot of ladino clover meal from which coumestrol had been originally isolated (Bickoff *et al.*, 1958) and which was known to be moderately estrogenic. The meal was assayed by the method of Beck and Braden (1951) which involves alkaline treatment of the initial alcoholic extract and by Pieterse and Andrew's procedure (1956) in which ethanol is employed as the extractant in the absence of alkali. The meal was also assayed by our proposed procedure. The sample appeared to be completely inactive when assayed by Beck and Braden's procedure. This probably reflects the destructive action of alkali

TABLE 6. COMPARISON OF PROPOSED PROCEDURE FOR PREPARATION OF ESTROGENIC EXTRACTS FROM DRIED MEAL WITH EARLIER REPORTED PROCEDURES

Extraction procedure	Average uterine weight, mg.	Number of animals
Beck and Braden (1)	10.0	10
Pieterse and Andrews (13)	28.3	10
Proposed procedure	27.0	10
Control	9.0	10

on coumestrol. Assay results by the proposed procedure were very similar to those obtained by the method of Pieterse and Andrews (table 6).

Mouse Bioassay

Preferences for the use of either immature or ovariectomized mice vary, according to reports in the literature (Bradbury *et al.*, 1954). We prefer the use of immature female mice for three reasons: ovariectomized mice are more costly, require more time prior to use, and are less sensitive to low doses of estrogen. This difference in sensitivity is illustrated by an experiment in which immature and ovariectomized mice were compared. No response was obtained with ovariectomized mice on a ration containing

TABLE 7. COMPARATIVE RESPONSE OF IMMATURE AND OVARIECTOMIZED MICE TO ORAL ADMINISTRATION OF DIETHYLSTILBESTROL (DES)

Test animals	Body weight		Amount of DES fed	Uterine weight	Number of animals
	Start	End			
	gm.	gm.	mcg.	mg.	
19- to 21-day-old mice	8.9	10.7	none	9.7	10
	9.0	10.0	0.1	30.2	10
Ovariectomized mice	23.9	24.9	none	22.3	10
(6 weeks old)	24.1	24.0	0.1	22.5	10

diethylstilbestrol, whereas a large uterine response was obtained with immature mice fed the same amount of diethylstilbestrol (table 7).

Since the dose-response curve is steeper for low doses of coumestrol we prefer to dilute our test extracts so that the average uterine weights do not exceed 35 mg. Furthermore, if the uterine weight is approximately 35 mg. or less, fluctuations due to uterine hydration are minimized and we do not find it necessary to slit and blot the uteri prior to weighing.

The strain of mice that we employ consume 10 gm. of food in 6 to 8 days. Maximum response to a given quantity of estrogenic concentrate appears to occur during this time interval. Therefore, the test dose is added to give a total food allowance of 10 gm. per mouse. They feed *ad libitum* until this amount of diet is consumed. However, the importance of autopsy prior to exhaustion of the food supply must be emphasized. Withholding the test diet for 24 hours prior to autopsy gave significantly lower uterine weights.

Housing the mice in individual cages to ensure that each animal ingested 10 gm. of food did not increase the uniformity of uterine-weight response. Therefore, all mice were caged and fed in groups of five. Lack of correlation between body weight and uterine weight in our experiments permitted us to express our results as the average of the individual uterine weights per mouse rather than per gram of body weight.

For each bioassay a negative and positive control were included. The negative control consisted of feeding the basic diet only. The positive control consisted of addition of a known amount of diethylstilbestrol (usually 0.1 mg. per 10 gm. of diet). During the period of more than one year, the average uterine weight of the positive control group was 31.96 mg. with slight fluctuations as shown in figure 1. This indicates a remarkable uniformity in response regardless of the time of year when the assay was run.

Test materials were administered orally to duplicate the normal route of ingestion by livestock. A laborious purification procedure would be required (Robinson, 1949) to test extracts by routes other than oral.

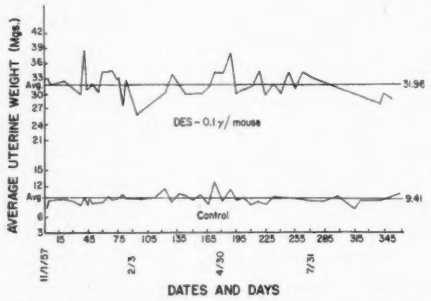

Figure 1. Average uterine weight response during a period of approximately one year.

Assay Procedure

1. Preparation of Extracts for Oral Administration. A. Fresh Forage. Freshly harvested plant material is cut into ½-inch lengths and thoroughly mixed. Several 10-gm. portions are then removed for moisture determination. A 400-gm. portion is placed in a paper bag and refrigerated until extraction for assay. Very little estrogenic activity is lost under these conditions after 24 hours. The estrogen concentrate is prepared from this forage sample by thoroughly disintegrating the fresh tissue with 1400 ml. of acetone in a commercial one-gallon blender. Blending the sample for about one minute is sufficient to macerate the plant material. The entire contents of the blender bowl are filtered through a coarse, sintered glass funnel 9 cm. in diameter, coated with a thin layer of diatomaceous earth. The filter cake is washed with an additional 400 ml. of acetone and the combined filtrate is concentrated under vacuum at a temperature of 60° C. or less to a volume of about 30 ml. This aqueous concentrate is transferred to a separatory funnel and extracted 4 times with 60-ml. portions of ethyl ether. The ether extracts are added to the flask employed for the evaporation and taken to dryness under vacuum.

The solid residue now adhering to and uniformly coating the inside of the flask employed for evaporation is dissolved in a minimum volume of acetone and alcohol and added to the mouse ration. The solvent is removed in a current of air with continuous stirring to assure uniform distribution of estrogen in the ration. The last traces of solvent are removed by keeping the sample under high vacuum for several hours. The weight of the test sample then is adjusted to give the desired equivalence of forage per gram of test ration. Most samples in our laboratory are initially tested at the equivalent level of 8 gm. of forage per 100 gm. of ration. If the response indicates that the forage sample is highly estrogenic, suitable dilutions can then be made so that the response obtained will fall within the standard curve range.

B. Dried Forage, Samples With Moderate Estrogenic Activity. For meal samples which require the extract from 1 to 10 gm. of plant material to cause at least a doubling of uterine weight, a 40-gm. sample of dried forage, ground to a fine meal, is extracted in a Soxhlet extractor with acetone for 24 hours. A large-sized paper extraction thimble (43 mm. x 123 mm.) is employed. The extract is concentrated on the steam bath to a small volume and added directly to about 40 gm. of mouse ration. Solvent is removed in a current of air with continuous stirring to ensure uniform distribution of the estrogen in the carrier. This is followed by vacuum drying for several hours to remove last traces of solvent. For preliminary screening of a new material the extract from 40 gm. of plant material is incorporated in sufficient mouse ration to give 50 gm. of test diet.

C. Samples With Low Estrogenic Activity. For samples which require the equivalent of more than 10 gm. of plant material per mouse to cause at least a doubling of uterine weight, a more purified extract is required. The meal is first extracted in the Soxhlet extractor for 24 hours with chloroform and the extract, which contains no measurable estrogenic activity, is discarded. After drying, the meal is re-extracted for 24 hours with acetone. This acetone extract may then be incorporated in the diet in levels calculated to yield the equivalent of 10 to 32 gm. of plant material per 10 gm. of mouse ration.

2. Bioassay. Immature female mice of the Dalswiss strain, 19 to 21 days of age, selected so that their weights range from 8 to 10 gm., are employed for test. The mice, in groups of five, are caged and fed the test diet *ad libitum* until a total of 50 gm. of ration has been consumed by the five mice. This usually requires 6 to 8 days. The mice are sacrificed and the freshly excised uteri are carefully trimmed and weighed without blotting or slitting. The estrogenic activity of the forage may be expressed in terms of stilbestrol or coumestrol equivalency by employing previously constructed dosage-response curves (table 8).

The data presented in table 8 were obtained by feeding graded increments of test material incorporated in the control diet to mice in groups of five. The slopes of the dose-response curves for coumestrol, stilbestrol,

and ladino clover meal are very similar. From these data it can be seen that stilbestrol is approximately 4,000 times as active as coumestrol and that this typical ladino clover meal has a potency equivalent to 5 micrograms of stilbestrol per 100 gm. of meal. If we assume that coumestrol is the predominant estrogenic substance in this forage, then we can calculate that it is present at a concentration of 20 mg./100 gm. of meal, or 0.02%.

TABLE 8. UTERINE RESPONSE TO GRADED LEVELS OF ESTROGEN

Diet	Quantity fed per mouse[a]	Uterine weight + S.E.[b]
	mcg.	mg.
Control	—	9.73±0.33
Coumestrol	100	13.74±0.73
Coumestrol	200	18.74±0.97
Coumestrol	300	25.68±1.05
Coumestrol	400	34.39±1.23
Stilbestrol	0.025	11.64±0.41
Stilbestrol	0.050	17.61±0.83
Stilbestrol	0.075	22.86±0.95
Stilbestrol	0.100	33.83±0.99
	gm.[c]	
Ladino clover extract	0.5	12.37±0.74
Ladino clover extract	1.0	22.61±1.67
Ladino clover extract	1.5	27.98±1.26
Ladino clover extract	2.0	36.15±3.51

[a] No. of animals=15 to 20 per group.
[b] S.E.=standard error mean.
[c] Equivalent weight of dry clover meal.

Summary

Since it has been found that dehydration lowers the apparent estrogenic activity of a forage, different techniques have been developed for preparation of extracts for bioassay. Freshly harvested forage is rapidly macerated in a mechanical blender with acetone in order to extract the estrogens. The dried samples are Soxhlet extracted with acetone for 24 hours. In either case the acetone extract is incorporated into the control diet and the solvent removed.

Estrogenic activity is evaluated by feeding the test diets to immature female mice and determining the increase in weight of the freshly excised uteri.

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INFLUENCE OF HORMONE IMPLANTS ON GAINS MADE ON NATIVE PASTURES AND IN THE FEEDLOT, AND ON CARCASS CHARACTERISTICS OF YEARLING STEERS [1, 2]

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HORMONE and hormone-like feed additives and implants increase the rate and efficiency of gain of steers in the feedlot. The increased gain and efficiency among feedlot cattle suggests extending these benefits to cattle producers in the range areas by using hormone implants to increase the gains of steers grazed on range.

The experiments reported here were undertaken to determine the effects hormone implants have on (1) summer gains of steers grazed under range conditions, (2) market feeder grade, (3) carryover effects in the feedlot, (4) time required in feedlot to reach choice slaughter grade, and (5) some carcass characteristics.

The studies were conducted at the Fort Robinson Beef Cattle Research Station, located in northwestern Nebraska. The principal forage species on the range are western wheatgrass, needle and thread, threadleaf sedge, prairie sandreed, Junegrass, blue grama, big bluestem, and little bluestem.

Materials and Methods

Experiment I. Yearling Hereford steers were purchased in the spring of 1957 and randomly allotted to three groups. One group was used as a control and not implanted. A second group was implanted with pellets containing 200 mg. progesterone and 20 mg. estradiol benzoate (implant A) [3] The third group was implanted with 24 mg. of stilbestrol. All implants were made in the ear. The steers were weighed on May 9 to initiate the experiment. The experiment was terminated and final weights were taken at the end of the grazing season, September 18, a period of 132 days.

Experiment II. A second lot of Hereford steers that had been wintered on range and protein supplement were randomly allotted to three groups. One group was used as a control. Another group was implanted with im-

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[3] Trade name, Synovex-S.

plant A. Another group was implanted with a product containing 60 mg. 17-alpha-hydroxy-progesterone caproate, 60 mg. testosterone enanthate, and 24 mg. estradiol valerate (implant B).[4] The steers were pastured for a 155-day period from April 23 to September 25. At the end of the pasture period, each summer-treatment group was redivided into three sub-groups, one group being a control, the second group given implant A, and the third group given implant B.

Only six feedlots were available for feeding the steers. Therefore, one-half of the steers from each fall-treatment group (48 steers balanced so that equal numbers from the previous summer treatments were included) were assigned to a lot. This permitted replicating the feed consumption data based on fall treatment and equalized groups for previous summer treatment but did not permit evaluation of feed consumption for the nine different summer and fall treatment combinations. The cattle were brought to a full feed during the first 28 days and then self-fed for the remainder of the feeding period.

Alfalfa hay was kept before the steers at all times and the concentrate was fed in large self-feeders. Initially, the steers were fed a concentrate mixture of 50% dried molasses beet pulp, 10% shelled corn, 38% oats and 2% molasses. The corn was gradually increased and the oats and molasses decreased until at the end of a month the steers were receiving 50% beet pulp and 50% corn. The 50–50 mixture was fed for about 1½ months; then, during a period of one week, the beet pulp was decreased to 25% and the corn increased to 75% and the mixture fed for the remainder of the feeding period.

As the steers reached an estimated choice slaughter grade, they were removed from the feedlot during the afternoon before shipment to market. The steers had access to feed but no water after 6 p.m. They were weighed about 1 p.m. the following day and trucked a distance of 430 miles to a packing plant. Individual carcass weights and measurements were obtained. Dressing percent was based on the weight at Fort Robinson and the hot carcass weight following slaughter.

One half of each carcass was ribbed between the 12th and 13th ribs. A meat grader of the U. S. Department of Agriculture graded the carcasses to the nearest one-third of a grade. One of the authors graded the ribeye for amount of marbling, independent of the U.S.D.A. grader. Ribeye tracings were made, and fat thickness was determined at three points over the ribeye.

Results and Discussion

The effect of hormone implants on daily gain of steers grazed on native range is shown in table 1. In Experiment I, involving 78 steers, both hormone implanted groups gained more than the control group. A statistical analysis of the gains indicated that the steers given implant A (progesterone

[4] Trade name, Rapigain.

and estradiol) gained significantly more (about 11%) than the controls, but that the stilbestrol implanted steers did not (P=5%). Implant A stimulated larger gains than stilbestrol, but the difference was not significant. The cattle were sorted into treatment groups after they were weighed off pasture in order that they could be observed for possible side effects. No differences were noted in the appearance or behavior of these steers.

The results of Experiment II (table 1) indicate that the steers given implant A gained significantly more than the control group. Implant B (progesterone, testosterone, and estradiol) did not increase gains signifi-

TABLE 1. EFFECT OF HORMONE IMPLANTS ON SUMMER PASTURE GAIN AND ON FEEDER GRADE

Items	Summer treatment			Standard deviation	LSD[a]
	Control	Implant A	Stilbestrol		
Experiment I (132 days)					
No. of steers	27	26	25		
Initial wt., lb.	506	496	508		
Final wt., lb.	736	752	758		
Daily gain, lb.	1.74	1.94	1.89	0.2946	0.19
Items	Summer treatment			Standard deviation	LSD[a]
	Control	Implant A	Implant B		
Experiment II (155 days)					
No. of steers	96	96	96		
Initial wt., lb.	457	462	465		
Final wt., lb.	745	774	758		
Daily gain, lb.	1.86	2.01	1.89	0.2608	0.09
Feeder grade[b]	10.0	10.0	10.3	1.17	0.4

[a] LSD is the least significant difference at the 5% level of probability as determined by the Q test (Snedecor, 1956) for three treatments.

[b] Feeder grades divided into high, medium, and low on the following scales: Fancy=15, 14, 13; Choice=12, 11, 10; Good=9, 8, 7; Medium=6, 5, 4.

cantly. The gains in these experiments resulting from hormone implants are consistent with results reported by other workers (O'Mary and Cullison, 1956; Thomas, Woodward, and Quesenberry, 1957; Walker, Smith, Koch and Cox, 1957). At the end of the grazing season the steers were scored individually for feeder grade by a committee of three men. No significant difference between treatments was found for feeder grade. After they were weighed and graded, the steers were sorted by treatment groups and observed for possible side effects of the treatments. The control group was quiet with little evidence of riding. There was no teat development and less than 10% showed a marked prominence about the tailhead. The group implanted with implant A was restless and constantly moved about the pen. Riding was very evident. There was slight teat development and about 50% of the steers showed marked prominence about the tailhead. The steers

TABLE 2. EFFECT OF HORMONE IMPLANTS ON FEEDLOT AND CARCASS CHARACTERISTICS

Group designation	1	2	3	4	5	6	7	8	9		
Fall treatment	Control	Control	Control	Implant A	Implant A	Implant A	Implant B	Implant B	Implant B	Standard	
Summer treatment	Control	Implant A	Implant B	Control	Implant A	Implant B	Control	Implant A	Implant B	deviation	LSD[a]
No. steers per treat.	32	32	32	32	32	32	32	32	32		
Initial weight, lb.	742	777	774	748	778	750	746	768	750		
Final weight, lb.	1100	1159	1128	1150	1158	1156	1126	1142	1128		
Days on feed	163	152	152	152	151	152	152	152	154		
Daily feedlot gain, lb.	2.21	2.53	2.36	2.66	2.54	2.69	2.52	2.49	2.47	0.384	0.30
Average daily gain, summer and feed lot, lb.	2.04	2.28	2.14	2.27	2.30	2.29	2.18	2.24	2.17	0.153	0.12
Carcass weight, lb.	670	707	686	703	711	704	690	700	689		
Carcass grade[b]	11.2	10.8	10.8	10.8	10.4	10.5	11.2	10.2	10.6	1.21	0.9
Marbling score[c]	11.0	10.9	10.6	10.4	10.1	10.2	10.8	10.0	10.4	1.10	0.9
Fat thickness, in.	0.64	0.63	0.68	0.65	0.68	0.67	0.70	0.64	0.70		
Adjusted fat thickness, in.[d]	0.65	0.62	0.68	0.65	0.67	0.67	0.70	0.64	0.70	0.17	0.33
Ribeye area, sq. in.	11.6	12.0	11.8	12.2	12.4	12.0	11.9	12.1	11.9		
Adjusted ribeye area[e]	11.8	11.9	11.9	12.2	12.3	11.9	11.9	12.1	11.9	0.92	0.72
Dressing percent	60.9	61.1	60.9	61.1	61.4	60.9	61.3	61.3	61.1	1.84	0.47

[a] LSD is the least significant difference at the 5% level of probability as determined by the Q test (Snedecor, 1956) for 9 treatments. Comparisons involving averages over several treatments as used in determining average summer or fall treatment effects require less difference for significance.

[b] Carcass grade system: Prime (high, medium, and low)=15, 14, 13; Choice=12, 11, 10; Good=9, 8, 7.

[c] Marbling scores: 15=Extremely abundant; 14=Very abundant; 13=Abundant; 12=Moderately abundant; 11=Slightly abundant; 10=Moderate; 9=Modest; 8=Small amount; 7=Slight amount.

[d] Fat thickness adjusted to constant carcass weight of 696 lb., using regression of 0.05 in. per 100-lb. increase in carcass weight.

[e] Ribeye area adjusted to constant carcass weight of 696 lb., using regression of 0.71 sq. in. per 100-lb. increase in carcass weight.

given implant B exhibited slight restlessness, riding being intermediate to the other two groups. There was no teat development. About 15% of the steers in the group had prominent tailheads.

The results of the feedlot phase for the 288 steers used in Experiment II are shown in table 2.

The 96 steers that were not implanted in the fall (groups 1, 2 and 3) averaged 2.37 lb. gain per day in the feedlot; those treated with implant A (groups 4, 5 and 6) averaged 2.63 lb. and those treated with implant B (groups 7, 8 and 9) averaged 2.49 lb. The steers receiving implant A made significantly greater gains than the controls and those receiving implant B. The steers treated with implant B gained more than those not implanted in the fall, the difference approaching statistical significance.

The average effect attributed to the summer treatment which carried over into the feedlot phase was estimated by averaging groups 1, 4 and 7; 2, 5 and 8; and 3, 6 and 9 (table 2). The average daily gains were (1) no summer implant, 2.46 lb.; (2) implant A, 2.52 lb.; and (3) implant B, 2.50 lb. These data indicate a slight, but non-significant advantage in feedlot gains for steers receiving implants at the beginning of the summer grazing season.

Statistical analysis of the feedlot gains indicated a significant interaction between summer and fall treatments. Thus, knowledge of the average effects due to summer and fall treatments was not sufficient to predict feedlot performance. Comparison of the separate group means with the expected values based on the average treatment effects indicates that the combination of an implant in one period and no implant in the other period (groups 2, 3, 4 and 7) came up to or exceeded expectations in feedlot gain. The groups receiving the same treatment in both periods, i.e. no implant, or two implants of the same product (groups 1, 5 and 9) gained less than expected on the basis of the average treatment effects. Since there were significant carryover effects from summer implants, the effectiveness of the treatments on feedlot gain should be assessed by comparing various treatment combinations with group 1 (no implant in either summer or feedlot phases) rather than the average of groups 1, 2 and 3.

The average gain of both summer and feedlot phases as a measure of the optimum increase to be gained from the use of hormone implants was considered. The similarity of average daily gains of 2.28, 2.27, and 2.30 lb. per day from groups 2, 4 and 5 and the gains of 2.14, 2.18, and 2.17 lb. per day from groups 3, 7 and 9 leads to the conclusion that one implant in either period will produce as much total gain (assuming similar time periods to those used in this study) as an implant in each period. Further, there was no significant advantage of using two different treatments (groups 6 and 8) as compared with the average effect of each hormone treatment.

The range in days-on-feed to reach choice slaughter grade was 113 to 176 days. Except for group 1, which received no implant in either phase of the experiment, there was little difference between various groups in days-

on-feed required to reach choice slaughter grade. Even though the steers receiving implant A on pasture made greater daily gains during the summer, they required as many days to reach choice grade as the cattle that did not gain as rapidly during the summer.

There were small but significant differences in carcass grade even though the animals were removed from the feedlots as they reached choice slaughter grade. The carcass grades from summer implanted steers were significantly lower than steers not implanted during the summer. The carcass grades of fall implanted steers were also lower though the differences were not quite statistically significant. The authors recognize that there are errors in estimating slaughter grade, but these errors are not likely to account for the significant differences observed in carcass grade for averages of 96 steers. It is assumed that the differences in carcass grade could not be predicted by differences in visual appraisal of the animals. The evidence provided by the data on marbling score and fat thickness are not contradictory to the above assumption. Carcass grade followed the pattern of marbling score quite closely. Present grading standards place considerable emphasis on marbling. The degree of marbling cannot be estimated accurately by visual appraisal of the live animal. There were no significant differences in fat thickness for the various treatments. Since slaughter grade is determined largely by degree of finish (at least among cattle of the conformation used here), the similarity of fat thickness is evidence that the differences in carcass grade were not related to differences that could be detected by slaughter grade.

Marbling score showed small but statistically significant differences for both summer and fall implant effects. Deans, *et al.* (1956) working with similar implants did not find significant differences in carcass grade or ether extract of the rib-eye muscle. Other workers reporting on stilbestrol-implanted steers have found a tendency toward lower carcass grades with less marbling (Andrews, Beeson, and Johnson, 1954; Clegg and Carroll, 1954, 1956).

Implanted steers had slightly larger rib-eye muscle area. Since part of the differences in rib-eye area are associated with differences in carcass size, the regression of rib-eye area on carcass weight was computed and the rib-eye area was adjusted to a constant carcass weight. A graph of the average rib-eye area for each 10-lb. interval in carcass weight showed no marked tendency toward curvilinearity. The linear regression of rib-eye area on carcass weight was 0.7 sq. in. per 100-lb. increase in carcass weight. The correlation between rib-eye area and carcass weight was 0.37. After adjusting to a constant carcass weight of 696 lb., the rib-eye area of the implanted groups was slightly larger but the differences between treatments were not significant.

Dressing percent did not differ significantly between treatments.

The data on relative feed consumption (table 3) are not as complete as might be desired since only six feedlots were available allowing replication

on the basis of fall treatment only. The implanted animals used less feed in producing their gain, but these differences were not statistically significant. However, the increased efficiency is consistent with evidence in other similar tests.

Observation of possible side effects due to the fall implants was made at the beginning and throughout the feeding period. There was no marked difference between the lots in amount of riding. Scores made 140 days after the feeding period started indicated no difference in tailhead prominence due to fall treatments. The differences in tailhead prominence due to summer treatment were still evident but reduced. No tendency toward teat development was noted.

TABLE 3. EFFECT OF FALL TREATMENT ON FEED CONSUMPTION AND TDN REQUIRED PER POUND OF GAIN

Item	Control	Implant A	Implant B
Number of steers	96	96	96
Hay consumed per day, lb.	6.4	6.5	6.5
Concentrate consumed per day, lb.	18.7	19.8	18.3
TDN consumed per day, lb.	17.6	18.5	17.4
TDN consumed per 100-lb. gain, lb.	744	705	697

Summary

The influence of hormone implants on daily gains and feeder grade of steers grazed under range conditions was studied in two experiments involving 78 and 288 steers. Implants of 24 mg. of stilbestrol and implants containing 200 mg. progesterone and 20 mg. estradiol benzoate increased daily gains by 8 to 11%. An implant containing 60 mg. 17-alpha-hydroxyprogesterone caproate, 60 mg. testosterone enanthate, and 24 mg. estradiol valerate increased daily gains about 2%, but this difference was not significant. There was no difference in feeder grade between the treatments.

After the summer grazing period the group of 288 steers were subdivided and part of the steers were reimplanted. The steers were then placed in feedlots and full-fed to choice slaughter grade. The implants, increased the rate of gain 12 to 22% when compared with gains of steers receiving no implant in either the summer or feedlot periods. One implant in either the grazing or the feedlot phase seemed to be as satisfactory as an implant in each phase so far as average daily gain over both periods was concerned. The steers that were not implanted in either period required 10 days longer to reach choice slaughter grade, but they did have a higher carcass grade than the other groups. There was no difference in days required to reach choice slaughter grade between the various treated groups.

There were small but significant differences in carcass grade due primarily to differences in marbling. There was no significant difference in rib-eye area, fat thickness, or dressing percent between the various treatments. The implanted steers required less feed per 100-lb. gain, but the differences were not statistically significant.

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INFLUENCE OF TRIIODOTHYRONINE ON FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF GROWING-FINISHING SWINE [1]

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THE effects of a hyperthyroid condition in swine upon growth and feed efficiency have been reported by Braude (1947), Turner (1947), Beeson *et al.* (1949), Perry *et al.* (1950) and Perry *et al.* (1951). Blaxter *et al.* (1949), in a review, reported that iodinated proteins fed to young pigs as a very small percentage of the ration resulted in some increase in growth rate and economy of gains.

Recently triiodothyronine has been suggested as a possible growth stimulant for swine. Triiodothyronine, a naturally occurring material of the animal body, is formed in the thyroid gland. Williams (1955) reported triiodothyronine was three times as calorigenic as thyroxine the first few days after administration, with the response to triiodothyronine beginning much quicker than the response to thyroxine. The metabolism of triiodothyronine and thyroxine is similar in many ways, but triiodothyronine is degraded much faster and disappears more than twice as fast as thyroxine. Shellabarger (1955) reported that in the rat L-triiodothyronine was about four times as effective as L-thyroxine in reducing thyroid enlargement caused by thiouracil feeding.

The purpose of this study was to determine the effects of feeding triiodothyronine to growing-finishing pigs on rate of gain, efficiency of feed utilization, various endocrine gland weights and certain carcass characteristics.

Experimental Procedure

Experiment I. In this experiment 32 weanling pigs of Duroc, Hampshire, Spotted Poland China and Yorkshire breeding were divided into eight replicated lots with four pigs per lot on the basis of sex, breed and initial weight. One replicate averaged approximately 50 lb. live weight initially and the other approximately 37 lb. The pigs were placed on feed June 15, 1957, and fed to a market weight of approximately 180 lb. The pigs were fed a corn-soybean oil meal ration (table 1) calculated to contain 15% protein. This ration was supplemented with 0, 125, 250 and 500 mg. triiodothyronine (sodium triiodo-L-thyronine) per ton of feed. The test lasted 82 days.

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Experiment II. Eighty weanling pigs of mixed breeding were divided into 16 replicated lots of 5 pigs each on the basis of sex, litter and initial weight and placed on feed December 14, 1957. One replicate averaged approximately 63 lb. live weight initially and the other approximately 52 lb. The first four lots in each replicate were fed a corn-soybean oil meal ration (table 1) calculated to contain 14% protein, and supplemented with 0, 25, 50 and 75 mg. triiodothyronine per ton of feed. The pigs in the remaining four lots of each replicate were fed a ration calculated to contain 21% protein, and supplemented with 0, 25, 50 and 75 mg. triiodothyronine per ton of feed.

TABLE 1. PERCENTAGE COMPOSITION OF BASAL RATIONS FED IN EXPERIMENTS I, II AND III

Experiment number	I	II		III
Level of protein, %	15	14	21	14
Ground yellow corn	76.4	80.9	61.4	80.9
Soybean oil meal	19.0	14.5	34.0	14.5
Steamed bonemeal	1.0	1.0	1.0	1.0
Ground limestone	1.0	1.0	1.0	1.0
Vitamin premix[a]	2.0	2.0	2.0	2.0
Trace mineral mix[b]	0.1	0.1	0.1	0.1
Iodized salt	0.5	0.5	0.5	0.5

[a] Vitamin A (10,000 i.u./gm.), 200.0 gm.; Vitamin D_2 (9,000 i.u./gm.), 180.0 gm.; Vitamin B_{12} supplement (9 mg./lb.), 1040 gm.; Riboflavin, 30 gm.; Pantothenic Acid, 30 gm.; Niacin, 180 gm.; Choline, 677 gm.; Folic Acid, 1.2 gm.; Pyridoxine, 2.8 gm.; Antibiotic supplement (10 gm. Chlortetracycline per lb.) 1816 gm.; and Soybean oil meal carrier, 32,244 gm.

[b] Manganous sulfate ($MnSO_4 \cdot H_2O$), 9.76%; Ferrous sulfate ($FeSO_4 \cdot H_2O$), 7.60%; Cupric sulfate ($CuSO_4 \cdot 5H_2O$), 7.50%; Zinc sulfate ($ZnSO_4 \cdot H_2O$), 8.00%; Cobaltous sulfate ($CoSO_4 \cdot H_2O$), 0.20%; Potassium iodide, 0.30%; and Calcium Carbonate carrier, 66.64%.

Individual pigs were removed from experiment and slaughtered as live weights reached approximately 190 lb. Carcass weights were taken after a 48-hour chill at 34° F. and dressing percentages determined. The average backfat thickness and carcass length were determined by usual carcass measurement procedures. The adrenal, thyroid and pituitary glands were removed at slaughter, cleaned and weighed.

Experiment III. In this experiment 40 Duroc x Spotted Poland China crossbred pigs were allotted into eight replicated lots of five pigs each on the basis of sex, litter and initial weight. One replicate averaged approximately 53 lb. live weight initially and the other approximately 44 lb. The pigs were placed on feed April 5, 1958 and fed to an average final weight of approximately 190 lb. The pigs in the first lot in each replicate received a corn-soybean oil meal basal ration calculated to contain 14% protein (table 1). The pigs in the second lot of each replicate received this basal ration supplemented with 50 mg. triiodothyronine per ton of feed. The pigs in the third lot of each replicate received the basal ration to a weight of 110 lb., at which time the ration was supplemented with 50 mg. triiodothyronine. The pigs in the fourth lot of each replicate were fed the

basal ration to an average weight of 150 lb., at which time the ration was supplemented with 50 mg. triiodothyronine per ton of feed.

In all experiments the pigs were fed in concrete pens, feed and water being supplied *ad libitum*. Individual weights were taken at weekly intervals and feed consumption data were obtained at four-week intervals and at the conclusion of the experiments. The analysis of variance was used in all experiments to determine statistical significance of the differences observed for the criteria studied.

TABLE 2. SUMMARY OF AVERAGE DAILY GAIN, DAILY FEED CONSUMPTION, AND FEED EFFICIENCY FOR PIGS OF EXPERIMENT I

Triiodothyronine per ton feed, mg.	0	125	250	500
		(Replicate I)		
Number of pigs	4	4	4	4
Initial wt., lb.	54.0	50.3	49.5	50.0
Final wt., lb.	184.7	194.0	186.0	174.3
Daily gain, lb.	1.59	1.75	1.66	1.52
Daily feed intake, lb.	5.12	6.03	5.83	6.00
Feed per lb. gain, lb.	3.22	3.45	3.51	3.95
		(Replicate II)		
Number of pigs	4	4	4	4
Initial wt., lb.	37.0	37.0	37.8	38.8
Final wt., lb.	180.0	174.0	174.0	175.5
Daily gain, lb.	1.74	1.67	1.66	1.67
Daily feed intake, lb.	5.75	6.19	5.69	5.87
Feed per lb. gain, lb.	3.30	3.71	3.44	3.52

Results and Discussion

Results of the three experiments are summarized in tables 2, 3, 4 and 5.

Experiment I. In Experiment I (table 2) there were no significant effects on daily gain due to triiodothyronine supplementation. At the 500 mg. level of supplementation there was a noticeable, though nonsignificant, decrease in the rate of gain, indicating that this level of supplementation may have resulted in an excessive hyperthyroid condition.

At all levels of triiodothyronine supplementation there was an increase in the feed required per lb. gain as compared to the basal ration, the pigs fed the 500 mg. level being the most inefficient. Triiodothyronine tended to increase the average daily feed consumption at all levels of supplementation.

Experiment II. The results of experiment II are summarized in table 3. Statistical analysis revealed no significant differences in weight gains due to triiodothyronine supplementation. Pigs in replicate 1 gained significantly faster ($P < .01$) than pigs in replicate II. This difference can be explained mainly on the basis of differences in initial weights.

The average daily feed consumption was quite variable for the different

treatments and no clear trends were apparent. Pigs in replicate I consumed significantly more feed per day ($P<.05$) than pigs in replicate II. Differences in feed conversion due to treatment or between replicates were not significant.

Fresh weights of the thyroid, adrenal and pituitary glands were obtained at slaughter. There was a tendency for the weights of the thyroid

TABLE 3. SUMMARY OF AVERAGE DAILY GAIN, DAILY FEED CONSUMPTION, FEED EFFICIENCY, GLAND WEIGHTS AND CARCASS CHARACTERISTICS FOR PIGS IN EXPERIMENT II

Level of protein, %	14				21			
Triiodothyronine per ton feed,[a] mg.	0	25	50	75	0	25	50	75
				(Replicate I)				
Number of pigs	4[b]	5	5	4[b]	5	5	5	5
Initial wt., lb.	65.8	63.2	62.8	61.5	63.2	64.2	62.8	63.6
Final wt., lb.	195.0	194.6	190.6	201.5	194.0	196.6	188.8	197.4
Daily gain, lb.	1.78	1.70	1.70	1.77	1.67	1.64	1.51	1.72
Daily feed intake, lb.	6.46	6.01	6.02	6.40	6.47	6.16	5.60	6.56
Feed per lb. gain, lb.	3.63	3.55	3.54	3.62	3.88	3.75	3.71	3.81
Thyroid wt., gm.	11.0	9.3	9.1	9.6	10.4	9.5	9.1	9.4
Adrenal wt., gm.	4.2	3.7	4.1	4.3	4.0	4.4	4.3	3.4
Pituitary wt., mg.	242.9	251.2	253.7	256.0	257.1	263.7	244.1	237.7
Chilled dressing percent	75.5	74.8	73.2	73.9	70.9	70.3	70.8	71.9
Backfat thickness, in.	1.52	1.52	1.52	1.48	1.35	1.42	1.26	1.40
Carcass length, in.	28.03	27.82	27.93	28.54	28.43	27.93	27.90	28.10
				(Replicate II)				
Number of pigs	5	5	5	5	5	5	4[b]	5
Initial wt., lb.	52.0	52.2	52.2	52.5	51.4	52.4	53.3	52.4
Final wt., lb.	192.2	193.6	187.8	186.4	194.8	193.0	192.5	188.6
Daily gain, lb.	1.57	1.71	1.63	1.47	1.64	1.63	1.50	1.48
Daily feed intake, lb.	5.65	5.69	5.38	5.48	5.75	6.43	5.58	5.23
Feed per lb. gain, lb.	3.58	3.34	3.30	3.73	3.50	3.94	3.73	3.54
Thyroid wt., gm.	8.7	9.4	9.3	7.6	10.9	9.6	7.0	9.3
Adrenal wt., gm.	4.4	4.5	3.6	4.2	4.7	4.2	4.7	5.0
Pituitary wt., mg.	258.0	275.6	268.8	263.3	275.4	278.2	269.1	289.8
Chilled dressing percent	73.6	71.6	73.1	73.5	71.1	70.5	71.1	69.7
Backfat thickness, in.	1.51	1.47	1.41	1.36	1.40	1.35	1.36	1.39
Carcass length, in.	28.05	27.78	28.25	28.13	28.48	28.45	28.66	28.63

[a] Sodium Triiodo-L-thyronine, Merck and Co., Inc.
[b] Two littermate pigs of Replicate I were removed early in the test on account of anal prolapse. One pig was removed from Replicate II early in the test on account of leg injury.

glands to decrease as the level of triiodothyronine increased. Weights of the adrenal and pituitary glands were quite variable both within and among treatments. There was no apparent pattern of effect produced on the gross development of these two glands by the triiodothyronine supplementation.

Examination of the carcass data indicated no statistically significant differences in dressing percent, backfat thickness or carcass length resulting from the feeding of the various levels of triiodothyronine.

Differences in the performance of pigs fed the two levels of protein are shown in table 4. Pigs fed 14% protein gained 1.67 lb. per day while those fed 21% gained 1.60 lb. This difference approached significance at

the 5% level of probability. The pigs fed low protein required 0.2 lb. less feed per lb. gain. This difference was highly significant. The pigs fed the 21% protein ration scoured intermittently during the experiment. They were never off feed, but the scouring probably contributed to poor feed conversion. Gland weights appeared unaffected by the level of protein in the ration. Dressing percentage was significantly higher ($P<.01$) and backfat was significantly thicker ($P<.01$) for the pigs fed 14% protein. The pigs fed high protein had somewhat longer carcasses at slaughter, but the differences were not statistically significant.

TABLE 4. SUMMARY OF AVERAGE DAILY GAIN, DAILY FEED CONSUMPTION, FEED EFFICIENCY, GLAND WEIGHTS AND CARCASS CHARACTERISTICS AS INFLUENCED BY PROTEIN LEVEL FOR PIGS IN EXPERIMENT II

Protein level, %	14	21
Number of pigs	38	39
Initial wt., lb.	57.6	58.1
Final wt., lb.	192.6	193.2
Daily gain, lb.	1.67	1.60
Daily feed intake, lb.	5.86	5.98
Feed per lb. gain, lb.**	3.53	3.73
Thyroid wt., gm.	9.2	9.3
Adrenal wt., gm.	4.1	4.3
Pituitary wt., mg.	259.1	264.3
Chilled dressing percent **	73.6	70.8
Backfat thickness, in.**	1.48	1.37
Carcass length, in.	28.06	28.32

** Difference significant at 0.01 level of probability.

Experiment III. In this experiment (table 5) a significant ($P<.05$) improvement in gains was produced by feeding 50 mg. triiodothyronine per ton of feed during the entire finishing period. This group of pigs also ate more feed than control pigs and pigs that were fed 50 mg. triiodothyronine after reaching 110 lb. live weight. There were no significant differences in feed efficiency resulting from the dietary treatments.

Thyroid weights, as in Experiment II, tended to be less when triiodothyronine was included in the ration. Adrenal and Pituitary weights were quite variable and appeared to be unaffected by the imposed treatments. Dressing percentage, backfat thickness and carcass length differences were not statistically significant in this experiment.

Summary

Three experiments, involving a total of 147 pigs, were conducted to determine the effect of various levels and periods of administration of triiodothyronine on the weight gain, feed conversion, gland weights and carcass characteristics of growing-finishing swine. Weanling pigs were fed levels of 25, 50, 75, 125, 250 and 500 mg. triiodothyronine/ton of

feed throughout the growing-finishing period. Pigs were also fed 50 mg. triiodothyronine commencing at 110 lb. and 150 lb. body weight. In one experiment a 14% protein ration was compared to a 21% protein ration. Results are as follows:

1. Levels of 125 mg. and above appeared to be too high by virtue of a reduction in the efficiency of feed conversion.

TABLE 5. SUMMARY OF AVERAGE DAILY GAIN, DAILY FEED CONSUMPTION, FEED EFFICIENCY, GLAND WEIGHTS AND CARCASS CHARACTERISTICS FOR PIGS IN EXPERIMENT III

Triiodothyronine per ton feed, mg.	0	50	50	50
Period of triiodothyronine feeding	—	Entire period	After 110-lb. body wt.	After 150-lb. body wt.
		(Replicate I)		
Number of pigs	5	5	4[a]	5
Initial wt., lb.	53.0	53.0	53.5	53.0
Final wt., lb.	192.6	203.8	188.0	197.4
Daily gain, lb.	1.59	1.81	1.57	1.69
Daily feed intake, lb.	5.36	5.95	5.07	5.87
Feed per lb. gain, lb.	3.37	3.29	3.23	3.47
Thyroid wt., gm.	9.6	7.5	7.6	7.3
Adrenal wt., gm.	2.8	3.3	2.9	3.2
Pituitary wt., mg.	240.8	249.4	241.3	244.0
Chilled dressing percent	73.6	73.4	73.0	73.1
Backfat thickness, in.	1.61	1.59	1.49	1.65
Carcass length, in.	28.15	28.70	28.87	28.40
		(Replicate II)		
Number of pigs	5	4[a]	5	5
Initial wt., lb.	44.2	44.3	44.2	44.2
Final wt., lb.	192.8	196.5	193.6	195.8
Daily gain, lb.	1.59	1.71	1.60	1.62
Daily feed intake, lb.	5.12	6.02	5.08	5.42
Feed per lb. gain, lb.	3.22	3.52	3.18	3.34
Thyroid wt., gm.	8.1	8.0	7.9	8.4
Adrenal wt., gm.	3.6	3.6	3.3	3.4
Pituitary wt., mg.	232.2	251.0	225.2	220.4
Chilled dressing percent	72.6	72.8	73.8	72.1
Backfat thickness, in.	1.48	1.47	1.44	1.51
Carcass length, in.	28.90	28.65	29.10	28.75

[a] One pig in Replicate I and one pig in Replicate II removed during first week of test on account of anal prolapse.

2. No consistent improvement in gains or feed conversion was elicited at levels of 25–75 mg., although in one instance a statistically significant improvement in gains ($P<.05$) was observed at a 50-mg. level of supplementation.

3. Triiodothyronine supplementation tended to reduce the size of the thyroid gland, but appeared to have no affect on the size of the pituitary and adrenal glands.

4. Carcass measurements revealed no significant effects due to triiodothyronine administration.

5. Triiodothyronine effects were not significantly influenced by the protein levels studied. However, pigs fed 14% protein rations gained faster, converted feed more efficiently ($P<.01$), gave higher dressing percentages ($P<.01$) and were thicker in backfat ($P<.01$) than comparable pigs fed 21% protein rations.

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EFFECT OF SODIUM SILICATE ON THE DEVELOPMENT OF URINARY CALCULI AND THE EXCRETION OF VARIOUS URINARY CONSTITUENTS IN SHEEP [1]

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MANY factors have been implicated in the formation of urinary calculi. Among the factors most consistently supported as predisposing the development of calculi are those that are concerned either directly or indirectly with mineral imbalances. Abnormal hormonal control or vitamin inadequacies, as well as an imbalanced mineral intake, could logically bring about such imbalances. Calcium, magnesium, and phosphorus are the minerals that have been implicated most frequently with calculi formation (Watchorn, 1932; Eveleth and Millen, 1939; Schneider and Steenbock, 1940; Elam *et al.*, 1956). Consequently, a large part of the work reported to date has been concerned with the development of calculi composed chiefly of calcium and magnesium phosphates.

Other urinary calculi that are less common, but which are encountered in various sheep flocks in the western states, are of the siliceous type. Several stones analyzed at this laboratory have been found to be of this type. Beeson *et al.* (1943) reported that this was the only type represented by four cases of calculi occurring during a two-year period in the University of Idaho flock. These workers were unable to show that the addition of sodium silicate to the drinking water of sheep had any effect on calculi development. Schneider *et al.* (1952) fed sodium silicate to sheep as 2.2% of a high-phosphorus ration and reported no increase in the incidence of urinary calculi. These workers used calcium and magnesium to protect sheep on high-phosphorus rations from calculi development, and found that sodium silicate tended to counteract this protective effect.

The experiment described herein represents an attempt experimentally to produce siliceous urinary calculi and to elucidate the factors which predispose their production.

Experimental Procedure

Twenty-four wether lambs were divided into four groups of six lambs each and fed the rations shown in table 1. The use of oats and prairie hay as the main dietary constituents for groups 1 and 2 resulted in rations relatively high in silica. In groups 3 and 4 oats were used but alfalfa hay served as the source of roughage. Alfalfa hay has been described

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by Newsom *et al.* (1943) as a protective feed. The rations of groups 2 and 4 were supplemented with 1.0% sodium silicate, and molasses was added to all rations to increase palatability.

The lambs were maintained in individual pens, and individual feed and water consumption records were kept. An attempt was made to equalize the feed consumption for the various groups. Average daily feed consumption per lamb was as follows: Group 1, 2.07 lb.; group 2, 2.01 lb.; group 3, 2.17 lb.; and group 4, 2.09 lb.

The experimental period during the fall and winter of 1957–58 was

TABLE 1. EXPERIMENTAL RATIONS FED TO SHEEP

Item	Ration number			
	1	2	3	4
Ingredient [a]				
Ground oats, %	43	42	43	42
Blackstrap molasses, %	5	5	5	5
Water, % [b]	2	2	2	2
Na_2SiO_3, % [c]	–	1	–	1
Prairie hay, %	50	50	–	–
Alfalfa hay, %	–	–	50	50
Minerals [d]				
Calcium, %	0.27	0.27	0.76	0.76
Magnesium, %	0.066	0.066	0.176	0.176
Phosphorus, %	0.25	0.25	0.27	0.27
Silica, %	2.96	3.34	0.84	1.21

[a] Trace mineralized salt and steamed bone meal were fed free choice.
[b] Water was used to facilitate the addition of sodium silicate to rations 2 and 4.
[c] Contains approximately 25% H_2O.
[d] These percentages are based on the chemical composition of the ration ingredients as determined in this laboratory.

of 115 days duration. During this time 24-hour urine samples were collected bi-weekly in rubber collection apparatus, and specific gravity, pH and turbidity measurements were made on the fresh samples. The samples were then preserved in polyethylene bottles by the addition of chloroform, and later analyzed for total solids, ash, calcium, magnesium, phosphorus and silica. Turbidity measurements were made in the Evelyn photoelectric colorimeter using a 660 mμ filter; total solids and ash were determined by conventional gravimetric methods; calcium and magnesium were determined by an adaptation of the ethylenediaminetetraacetate (EDTA) titration method described by Hach Chemical Company (catalog no. 4) for water analyses; silica was determined by a modification of the molybdenum blue method of Volk *et al.* (1958). Blood was collected twice during the last two weeks of the experimental period and phosphorus was determined on plasma and urine by the method of Fiske and SubbaRow (Hawk *et al.*, 1947). Plasma calcium was determined by the Clark-Collip modification of the Kramer-Tisdall method (Hawk *et al.*, 1947).

TABLE 2. CHEMICAL ANALYSIS OF URINARY CALCULI

Group no.	Sheep no.	Loss on ignition	Ca	Mg	PO_4	SiO_2
		%	%	%	%	%
1	2[a]	22.6	—	—	—	71.2
2	9[a]	30.7	22.9	1.3	35.4	—
2	11[b]	(Stone not recovered)				

[a] Stones were recovered at the time of slaughter.
[b] Died after 103 days on experiment.

At the termination of the experiment the sheep were slaughtered, and the urinary tracts were examined for stones.

Results and Discussion

During the course of the experimental period one sheep in group 2 died as a result of a ruptured bladder. The stone was not recovered. At the time of slaughter stones were found in the urinary tracts of two sheep from groups 1 and 2. Chemical analyses showed that silica was the principal constituent of the stone from the wether in group 1. The stone recovered from the wether in group 2 appeared to be primarily calcium and magnesium phosphates (table 2). No calculi were found in any of the sheep receiving alfalfa hay, which is in agreement with the hypothesis that alfalfa hay is a protective feed.

The average daily water consumption per sheep in the various groups was as follows: Group 1, 4.02 lb.; group 2, 3.82 lb.; group 3, 4.33 lb.;

TABLE 3. CHEMICAL AND PHYSICAL CHARACTERISTICS OF URINE AND PLASMA OF SHEEP ON URINARY CALCULI EXPERIMENT

Item	Group 1	Group 2	Group 3	Group 4
No. sheep per group	6	6	6	6
No. sheep developing calculi	1	2	0	0
Urine volume, ml./day	1205	1101	1244	1193
Urine pH	8.73	8.72	8.81	8.78
Urine specific gravity	1.038	1.041	1.045	1.040
Urine turbidity, L at 660 mμ	0.540	0.351	0.400	0.454
Urine solids, g./100 ml.	4.65	4.89	5.44	4.41
Loss of urine solids on ignition, %	68.5	72.8	66.0	70.0
Urine calcium, mg./day[a]	68.2	29.6	60.7	74.7
Urine magnesium, mg./day[b]	332	285	599	439
Urine phosphorus, mg./day[c]	48.0	36.7	5.7	5.1
Urine silica, mg./day	191	168	164	168
Plasma calcium, mg./100 ml.[d]	9.24	9.66	10.05	11.10
Plasma phosphorus, mg./100 ml.[e]	8.14	8.18	6.51	6.25
Water consumption (lb./day)	4.02	3.82	4.33	5.19

[a] L.S.D. at P.05=26.3; P.01=34.8.
[b] L.S.D. at P.05=143; P.01=189.
[c] L.S.D. at P.05=25.0; P.01=33.0.
[d] L.S.D. at P.05=0.55; P.01=0.74.
[e] L.S.D. at P.05=0.86; P.01=1.15.

and group 4, 5.19 lb. Water consumption appeared to be slightly increased by the feeding of alfalfa hay. A further increase was obtained on alfalfa hay, but not prairie hay, by the inclusion of sodium silicate.

Results of urine analyses presented in table 3 show only slight differences among the various groups with respect to urine volume, pH, specific gravity and total solids. Some significant differences were observed, however, in urinary mineral excretions. Sodium silicate lowered urinary calcium excretion when fed with prairie hay but not when fed with alfalfa. The 29.6 mg. of calcium excreted per day by sheep receiving the prairie hay-silicate ration (group 2) represents a 56.6% reduction ($P<0.01$) from the 68.2 mg. excreted by sheep receiving the prairie hay-control ration (group 1).

Magnesium excretion tended to be reduced in both groups receiving sodium silicate. The reduction amounted to 14.1% in the prairie hay group (group 2) and 26.7% ($P<0.05$) in the alfalfa hay group (group 4). On a molar basis sodium silicate reduced the urinary excretion of calcium plus magnesium by 18.8% in the prairie hay group and 23.8% in the alfalfa hay group.

When sodium silicate was omitted from the rations (groups 1 and 3) average urinary calcium values were approximately equal. Average urinary magnesium, however, was 80.4% higher when alfalfa was fed (group 3) than when prairie hay was fed (group 1).

The urinary excretion of phosphorus was also closely related to the type of roughage fed. The average daily phosphorus excretions were 48.0 and 36.7 mg., respectively, in groups 1 and 2 (prairie hay) and only 5.7 and 5.1 mg., respectively, in groups 3 and 4 (alfalfa hay). Average plasma phosphorus values showed a similar trend (table 3).

It is of interest that the three sheep that developed urinary calculi in this experiment excreted more phosphorus in the urine than any of the other sheep receiving the same rations (figure 1), 125 mg. per day as compared with 19 mg. for the other nine sheep in groups 1 and 2. Further, the two sheep that developed urinary calculi and lived had an average plasma phosphorus level of 9.72 mg. per 100 ml. of plasma while the calculi-free sheep on the same rations had an average value of only 7.81 mg.

These data indicate that variations in phosphorus metabolism may play an important role in the production of urinary calculi. This is in agreement with the conclusion of Lindley *et al.* (1953) concerning phosphorus as a causative factor.

Summary

Wether lambs were fed rations containing prairie hay or alfalfa hay as a source of roughage, with and without added sodium silicate, in an attempt to elucidate the factors which predispose the production of urinary calculi. Three of the lambs fed prairie hay, but none of those fed

alfalfa, developed urinary calculi. Those receiving prairie hay were characterized by higher excretion of phosphorus and lower excretion of magnesium in the urine.

Elevated plasma and urine phosphorus values were correlated with the development of urinary calculi in each animal for which determinations were made.

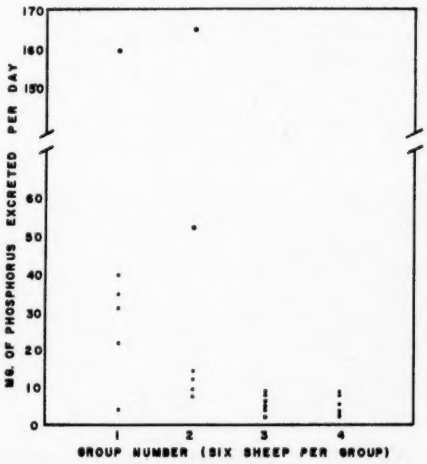

Figure 1. The distribution of average urinary phosphorus excretion values within groups of wethers receiving various treatments. Group 1, prairie hay-basal ration; group 2, prairie hay-silicate ration; group 3, alfalfa hay-basal ration; and group 4, alfalfa hay-silicate ration.

o represents wethers that developed urinary calculi.

• represents calculi-free wethers.

Sodium silicate feeding had no significant effect on calculi formation. It did, however, significantly lower urinary calcium excretion on the prairie hay ration and urinary magnesium excretion on the alfalfa ration.

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EFFECT OF INTENSITY OF GRAZING UPON NUTRITIVE CONTENT OF THE DIET

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Introduction

THE salt desert ranges of the Intermountain area cover about 41 million acres and furnish forage for 4 to 5 million sheep and many cattle for 4 to 6 months each winter. Some of these ranges are stocked heavily, particularly during periods of drought (figure 1).

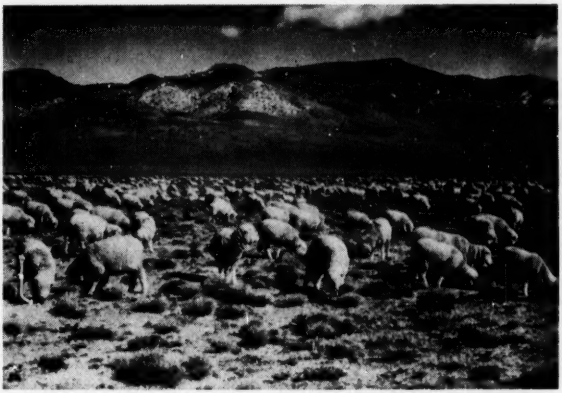

Figure 1. A typical salt desert range, with sheep grazing over the area rather closely a second time.

Many forage plants of this range are either borderline or deficient in important nutrients (Cook and Harris, 1950). Many operators do not use supplements on the range unless forage conditions are unfavorable, or weather is severe. It is important for stockmen and range managers to know what effect grazing intensity has on the nutritive content of the grazing animal's diet.

Several studies have been reported on the effect of intensity of grazing on gains made by livestock. Sarvis (1941) reported that the gain by two-year-old steers on the northern Great Plains of North Dakota was considerably more under a system of light stocking than under one of

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heavy stocking. Similar results were reported in Utah on crested wheatgrass pastures (Frischknecht *et al.*, 1953), on the short-grass prairie of southern Alberta, Canada (Clark *et al.*, 1943), in the northern Rocky Mountains by Woolfolk and Knapp (1949), and on the salt desert shrub in southern Utah (Hutchings and Stewart, 1953). These differences in gains appear to be a result of reduced daily intake and forced utilization of the less nutritious portions of plants when overstocking occurs (Cook *et al.*, 1953).

The present study was conducted on typical salt desert range in southwestern Millard County, Utah. The experiment covered the winter grazing season, starting about October 20, 1956, and terminating about March 3, 1957.

Method and Procedure

On each study area there were located three enclosures of approximately equal grazing capacity. These were of 3 to 5 acres, depending on the type and amount of vegetation present. One of the three was used for an adjustment pen in which the sheep were allowed to graze for 4 days. The remaining two were used for the actual field trials. Four wether sheep in one enclosure, and eight in the other, were grazed for 8 days. Each enclosure was enclosed by a triangle-mesh fence which was tightened by zigzagging steel posts on opposite sides. After the trial had been completed, the fences were moved to another study area.

During the trial, four sheep in each area were equipped with special fecal bags and harnesses. There was no definite degree of utilization sought with these different intensities of stocking. The utilization on each forage species in each enclosure was estimated at the end of 4 days and again at the end of 8 days. The utilization obtained was such that at the end of 4 days of grazing, the intensity varied from light to moderate in one enclosure, and moderate to heavy in the other. At the end of 8 days of grazing, the more lightly stocked enclosure was generally judged to be moderately grazed, and the heavily stocked enclosure was heavily grazed.

Forage samples for chemical analysis were collected daily while the sheep were grazing. The collector observed the sheep closely while they were grazing, and attempted to collect plant portions similar to those which the sheep were eating. Many small random plucks were taken over the areas. On mixtures, each species was collected separately and the diet weighted according to production and utilization of each species.

Feces were usually collected twice daily. The feces of each sheep were stored in separate containers and weighed at the end of each four-day period before being composited for chemical analysis.

Daily forage intake and digestion coefficients were determined by use of the lignin-ratio technique (Cook *et al.*, 1951).

TABLE 1. BOTANICAL COMPOSITION, UTILIZATION AFTER 8 DAYS, AND COMPOSITION OF THE DIET OF GRAZING SHEEP UNDER LIGHT AND HEAVY STOCKING DURING THE WINTER GRAZING SEASON

Species[a]	Range composition	Light stocking		Heavy stocking	
		Utilization	Diet	Utilization	Diet
	%	%	%	%	%
Mixtures					
Area I					
Sand dropseed	25.4	45.0	34.1	92.5	32.4
Indian ricegrass	28.3	65.0	55.1	95.0	22.9
Shadscale	8.9	3.0	0.9	17.0	3.4
Winterfat	14.2	11.7	5.1	53.3	15.9
Galleta grass	11.5	10.0	3.6	90.0	24.8
Brigham tea	11.7	3.3	1.2	5.0	0.6
Totals and averages	100.0	33.3	100.0	70.4	100.0
Area II					
Winterfat	67.2	25.0	86.6	82.5	69.5
Four-wing saltbush	7.8	30.0	11.9	80.0	7.0
Shadscale	4.6	1.5	0.5	15.0	1.1
Desert molly	18.5	0.0	0.0	60.0	20.0
Black sage	1.9	10.0	1.0	80.0	2.4
Totals and averages	100.0	19.4	100.0	74.9	100.0
Area III					
Sand dropseed	78.2	50.0	77.5	95.0	94.6
Indian ricegrass	10.5	90.0	18.8	0.0	0.0
Shadscale	2.7	7.0	0.4	18.0	0.9
Winterfat	8.4	20.0	3.3	40.0	4.5
Yellowbrush	0.2	0.0	0.0	0.0	0.0
Totals and averages	100.0	50.4	100.0	78.2	100.0
Area IV					
Galleta grass	46.4	50.0	51.1	90.0	48.4
Sand dropseed	5.1	90.0	10.1	0.0	0.0
Winterfat	43.0	40.0	37.9	80.0	50.2
Shadscale	5.0	7.0	0.9	18.0	1.4
Brigham tea	0.5	0.0	0.0	0.0	0.0
Totals and averages	100.0	45.4	100.0	77.1	100.0
Pure stands					
Winterfat	100	20	100	70	100
Four-wing saltbush	100	15	100	60	100

[a] Sand dropseed (*Sporobolus cryptandrus*), Indian ricegrass (*Oryzopsis hymenoides*), shadscale (*Atriplex confertifolia*), four-wing saltbush (*Atriplex canescens*), winterfat (*Eurotia lanata*), galleta grass (*Hilaria jamesii*), Brigham tea (*Ephedra nevadensis*), desert molly (*Kochia vestita*), black sage (*Artemisia nova*), yellowbrush (*Chrysothamnus stenophyllus*).

Results and Discussion

Botanical Composition of the Diet. The botanical composition of the diet is shown in table 1. Area I represents averages from three separate trials in a grass-shrub mixture; area II represents averages from two trials in a shrub mixture; and areas III and IV each represent a single trial in a grass-shrub mixture.

In most cases, where grasses were present, they were grazed considerably heavier than shrubs. In areas I and II, the shrubs were only lightly used under light grazing; whereas grasses were used considerably heavier. In areas III and IV under light use during the first 4 days of grazing, the

TABLE 2. AVERAGE CHEMICAL COMPOSITION OF THE DIET OF SHEEP GRAZING AT DIFFERENT INTENSITIES ON SALT DESERT MIXTURES AND PURE STANDS DURING THE WINTER GRAZING SEASON

Item	Utilization[a]	Ether extract	Total protein	Ash	Lignin	Cellulose	Other carbohydrates	Gross energy
	%	%	%	%	%	%	%	Kcal./lb.
Mixtures								
Area I	33	2.0	4.8	8.7	8.4	34.9	40.8	1894
	70	1.5	5.0	6.8	9.8	32.1	44.6	1868
Area II	19	3.3	10.6	10.1	12.6	21.1	42.5	1890
	75	2.4	9.0	12.3	15.6	15.2	45.5	1884
Area III	51	1.3	3.3	8.3	6.6	40.0	40.5	1836
	79	0.7	3.7	5.9	9.0	40.9	39.8	1892
Area IV	45	2.1	5.4	11.7	9.3	24.8	46.7	1806
	77	2.1	5.6	9.5	9.8	26.4	45.6	1885
Pure stands								
Winterfat	20	2.4	8.5	9.8	9.8	23.5	46.0	1856
	70	2.2	8.0	11.1	13.3	21.2	44.2	1843
Four-wing saltbush	15	2.3	12.6	16.2	9.7	13.7	45.5	1824
	60	2.3	7.7	10.7	13.7	22.8	42.7	1810

[a] Represents average percent of available forage consumed.

grasses were used rather heavily, and little remained to be grazed during the second 4 days; so the diet shifted somewhat to shrubs.

As intensity of grazing increased, a change in preference from one species to another was shown. Some plants were eaten closely before others were touched. Thus, increased intensity of grazing on plant mixtures involves grazing certain species closer and a change in pereference from one species to another.

Chemical Content of the Diet. In all cases, lignin increased in the diet as intensity of grazing increased (table 2). This is what would be expected, because the bases of plants are higher in lignin; and, a shift from grass to shrubs with increased grazing intensity also increases lignin in the diet, since shrubs are considerably higher in lignin than grasses. In most trials total protein, ether extract, gross energy, and phosphorus decreased in the diet with increased utilization. This was consistently true on trials where only pure stands were grazed.

On pure stands of winterfat, the content and digestibility of cellulose decreased with increased intensity of grazing; whereas, on four-wing saltbush, the reverse was true. In another study (Cook *et al.*, 1958) dealing with harvesting the current year's growth at various intensities, it was found that the upper tips of the current year's growth of winterfat were considerably higher in cellulose than the base of the twig. In the case of four-wing saltbush, the base of the current year's growth was considerably

TABLE 3. AVERAGE DIGESTIBILITY OF THE COMPONENTS IN THE DIET OF SHEEP GRAZING AT DIFFERENT INTENSITIES ON SALT DESERT MIXTURES AND PURE STANDS DURING THE WINTER GRAZING SEASON

Item	Utilization[a]	Ether extract	Total protein	Cellulose	carbohydrates	Gross energy	Dry matter
	%	%	%	%	%	%	%
Mixtures							
Area I	33	50.9	35.6	75.8	60.8	56.1	53.4
	70	44.6	33.1	65.6	55.3	47.7	42.7
Area II	19	41.9	54.0	51.3	52.7	41.1	36.2
	75	30.6	46.7	32.4	43.3	33.4	24.3
Area III	51	41.4	22.4	80.8	66.6	62.1	61.7
	79	47.5	22.7	74.6	52.8	50.8	47.1
Area IV	45	47.7	36.0	59.1	54.2	46.1	41.7
	77	41.5	37.0	60.8	54.6	47.7	39.7
Pure stands							
Winterfat	20	53.4	53.9	50.2	50.3	45.3	31.1
	70	28.7	43.2	37.3	37.7	31.2	20.9
Four-wing saltbush	15	45.7	64.4	46.0	56.0	49.6	41.8
	60	40.8	44.4	50.4	36.7	34.4	12.5

[a] Represents average percent of available forage consumed.

higher in cellulose than the tip. Thus, the two species of forage plants differed with respect to the location of nutrients in their tissues.

In areas I, III, and IV, the protein content of the diet increased with increased utilization (table 2). This was largely a result of a change in plant preference. As the trials progressed, the animals on the heavily stocked enclosure made rather sudden shifts from some grass species to shrubs. As the highly preferred species became closely eaten, the animals started eating another species that had previously been eaten sparingly.

Digestibility of the Constituents in the Diet. In most trials the digestibility of the ether extract material, other carbohydrates, gross energy, and dry matter was considerably decreased as the intensity of utilization was increased (table 3). On pure stand, the digestibility of all constituents except cellulose decreased with increased intensity of use. In trials involving plant mixtures, the digestibility of protein, in some cases, increased slightly as intensity of utilization increased (table 3). This was true in four

of sixteen trials, and generally was associated with increased protein in the diet as a result of a change in the species consumed.

Daily Intake. In all trials the daily consumption of dry matter was substantially reduced by intense grazing. Forced utilization of secondary species, and of more fibrous portions of the plants, always decreased daily forage intake. Occasionally the decrease was as much as 25% (table 4). In general, the decrease in consumption of dry matter resulted in decreased

TABLE 4. DAILY CONSUMPTION OF DRY MATTER, METABOLIZABLE ENERGY, DIGESTIBLE PROTEIN, AND PHOSPHORUS IN THE DIET OF SHEEP GRAZING SALT DESERT MIXTURES AND PURE STANDS AT DIFFERENT INTENSITIES DURING THE WINTER GRAZING SEASON, COMPARED WITH THE RECOMMENDED RANGE STANDARD

	Utilization[a]	Dry matter consumed	Metab. energy	Metab. energy	Dig. protein	Dig. protein	Phos.	Phos.
	%	lb.	Kcal./lb.	Kcal.	%	lb.	%	oz.
Mixtures								
Area I	33	4.41	955	4211	1.71	.075	.04	.028
	70	3.50	774	2709	1.66	.058	.04	.022
Area II	19	3.83	627	2401	5.72	.219	.09	.055
	75	3.32	478	1587	4.20	.139	.10	.053
Area III	51	4.81	1037	4986	.74	.018	.03	.023
	79	3.61	868	3135	.84	.017	.04	.023
Area IV	45	3.95	669	2642	1.93	.076	.05	.032
	77	3.53	756	2670	2.08	.073	.06	.034
Pure stands								
Winterfat	20	3.07	676	2075	4.58	.141	.10	.049
	70	2.84	435	1235	3.46	.098	.10	.045
Four-wing saltbush	15	4.61	748	3448	8.11	.374	.09	.066
	60	4.52	545	2464	3.41	.154	.06	.043
Range standard[b]		3.60	663	2386	4.4	.158	.17	.098

[a] Represents average percent of available forage consumed.
[b] Requirements suggested for a 130-lb. ewe in gestation (Cook *et al.*, 1954).

consumption of all nutrients. However, it should be pointed out that this was not always true. In some cases, even though the consumption of dry matter decreased with increased utilization, the actual pounds of digestible nutrients increased as intensity of utilization increased. This was a result of increased percentage in the diet and increased digestibility. Thus, a change in species consumption resulting from increased intensity of utilization may increase the consumption of a particular nutrient. In several cases (table 4) the metabolizable energy and digestible protein were adequate under light utilization, but were deficient under heavy utilization.

It should be emphasized that proper utilization of the forage more nearly balances the diet of the grazing animal. Heavy grazing imposes the necessity for more supplementation to meet the requirements for optimum production of range livestock. However, supplementation is no substitute

for good range management because heavy grazing will lead to poor range condition and decreased forage production.

Summary

Digestion trials were conducted on typical desert ranges in southern Utah to study the effect of intensity of grazing upon the nutritive content of a sheep's diet. Sixteen trials were conducted during the winter grazing season, October 1956, to March 1957.

Sheep were grazed on two enclosures of approximately equal size. Four sheep were grazed in one enclosure, and eight in the other. Four sheep in each enclosure were equipped with bags for collection of feces. Forage samples of the parts of the plants being eaten by the sheep were collected daily. Digestibility coefficients and daily consumption were calculated by means of the lignin-ratio technique.

Lignin in the diet increased in all trials as intensity of grazing increased. On pure stands, protein, gross energy, ether extract, and phosphorus tended to decrease as intensity of grazing increased. However, on some of the mixtures, a dietary change from one species to another, with increased intensity of utilization, increased the protein, phosphorus, and cellulose content of the diet.

In most trials, the digestibility of the nutrients in the diet was considerably reduced by heavy grazing. Forage intake was markedly reduced by heavy grazing in all trials.

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GROWTH AND EXTERNAL CHARACTERISTICS OF JERSEYS AND RED SINDHI-JERSEY CROSSBRED FEMALES [1]

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ONE of the approaches to the problem of developing dairy cattle adaptable to the Southern United States has involved the introduction of Red Sindhi cattle (a Zebu type from India). Various combinations of Red Sindhi have been made with Brown Swiss, Holsteins and Jerseys. These studies have been conducted by the U. S. Department of Agriculture and in cooperative projects with the State Agricultural Experiment Stations of Georgia and Louisiana.

In order to determine the effect of various degrees of Sindhi inheritance on growth as well as a part of the process of endeavoring to determine the physiological and/or anatomical characteristics that make Zebu type cattle and their crosses more heat tolerant, body weight, various body dimensions and surface area measurements were studied. A comparison of some of the Red Sindhi-Jersey F_1 crossbreds with Jerseys in the Beltsville herd have been reported previously (McDowell *et al.*, 1954). This paper deals with the variation in growth, body dimensions and surface area of all the various combinations of Red Sindhi and Jerseys as compared to the Jerseys at three stations.

Methods

Data used in this study were collected from the projects at the Agricultural Research Center, Beltsville, Maryland; the Iberia Livestock Experiment Station, Jeanerette, Louisiana; and the Georgia Coastal Plain Experiment Station, Tifton, Georgia. The breed groups consisted of purebred Jerseys and groups of ¾ Jersey-¼ Sindhi, ⅝ Jersey-⅜ Sindhi, ½ Jersey-½ Sindhi (first generation), ½ Jersey-½ Sindhi (second generation), ¼ Jersey-¾ Sindhi and ⅛ Jersey-⅞ Sindhi crosses. Unfortunately, data on purebred Red Sindhi females were not sufficient to warrant being included. For simplicity in this paper the stations will be referred to as Beltsville, Jeanerette and Tifton and the breed groups as Jerseys, ¾ J, ⅝ J, F_1, F_2, ¼ J and ⅛ J, respectively.

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The F_1 crosses were produced by mating Red Sindhi males to Jersey females; and ¾ J at Jeanerette and Tifton were from mating F_1 crossbred males to Jersey females but the ¾ J group at Beltsville also included reciprocals; the ⅝ J crosses at Jeanerette were produced by mating Jersey males to ¼ J females and those at Tifton were from F_1 crossbred males mated to ¾ J females; the F_2 group was produced by *inter se* matings of F_1's; the ¼ J were produced by backcrossing F_1 females to purebred Sindhi males and the ⅛ J were a result of a second backcross to Sindhi males.

The purebred Jerseys were animals in the herds at the same time as the crossbreds and represent a random sample since there was no selection at the young ages. They were slightly inbred but not sufficiently to warrant consideration in this study. The same applies to the crossbred groups except for the ⅛ J groups which had from 6-12% inbreeding.

At each station all crossbreds were reared and managed in the same manner as the purebred Jerseys. Whole milk was fed for the first 4 to 8 weeks. This was followed by skim milk feeding up to 6 months at Beltsville and Jeanerette, and the use of a calf starter at Tifton. From about 3 weeks of age the calves were fed hay and grain. The heifers went on pasture in season after 12 months of age until shortly before calving. Supplementary grain was fed most of the time in all herds.

The body weights and body dimensions used in this study were taken within 3 days before or after the animals were 6, 12 and 18 months of age and 3 months after calving during first lactation. In addition, body weights taken at 30-day intervals from birth to 21 months of age in the Beltsville herd were used.

From the Jeanerette and Tifton herds eight body dimensions were available for estimating height, length, width, depth and circumference. Twenty-one additional external measurements were available on the Beltsville groups. These included 23 dimensions for determining more extensively the characteristics mentioned above and six other measurements which were used to characterize the head, size of shin-bone and slope of rump. The body dimensions were taken in the same manner as described by Swett and Graves (1939) with the exception of length from withers to hips, total body length and length and width of head which, in this case, were taken with calipers instead of a tape. All dimensions except length of foreleg were direct measurements. Length of foreleg was taken as the difference between height at withers and depth of forechest.

Body surface area measurements were made using a surface integrator according to a routine which has been described by McDowell *et al.* (1953).

Results and Discussion

Body Weight. The means for the Jersey groups are given in table 1. The Beltsville Jerseys follow very closely the growth standard for Jerseys

at Beltsville (Matthews and Fohrman, 1954) from birth through first lactation. The groups from the other two stations were 7-8% below the standard at birth and remained as such for the first 6 months. The Tifton Jerseys were 11% less than the standard at 12 months and remained at about this level throughout first lactation. At 12 months the Jeanerette group was about 35% below the standard but showed some increase by 18

TABLE 1. MEAN BODY WEIGHTS OF JERSEYS AND THE DIFFERENCES FROM THE JERSEY MEANS FOR 3/4 J, 5/8 J, F_1, F_2, 1/4 J AND 1/8 J RED SINDHI-JERSEY CROSSES AT VARIOUS AGES IN THE JEANERETTE, BELTSVILLE AND TIFTON HERDS

Breed group	6 months		12 months		18 months		First lactation[a]	
	No.[b]	Mean Diff. (lb.)	No.	Mean Diff. (lb.)	No.	Mean Diff. (lb.)	No.	Mean Diff. (lb.)
Jeanerette								
Jersey	41	238	32	343	31	476	27	671
3/4 J	23	0	16	47**	14	29	10	—11
5/8 J	5	25**	5	99**	4	105**		
F_1	28	22**	35	60**	48	53**	16	48**
F_2	12	—10	10	31	11	—5	7	—91**
1/4 J	14	—10	17	45**	17	29	9	6
1/8 J	7	—40**	4	—52**	4	—109**		
Beltsville								
Jersey	59	273	52	501	50	653	40	857
3/4 J	23	30**	15	9	17	9	7	—3
F_1	49	51**	46	53**	44	28	39	25
1/4 J	20	—7	23	—38*	12	—51*	14	—80*
1/8 J	10	—36**	9	—93**	5	—137**		
Tifton								
Jersey	78	265	81	459	73	599	44	731
3/4 J	22	3	23	22	20	63**	21	75**
5/8 J	7	19	8	43*	7	74**	5	33

[a] Three months after calving.
[b] Number of animals.
* Significantly different from Jersey mean at the 5% level.
** Significantly different from Jersey mean at the 1% level.

months and during first lactation when they were then 25-27% lower than the standard.

Further evidence for this retardation in growth is shown in rate of gain. The average daily gains during the periods from birth to 6 months and from 12 to 18 months were very close to the standard at all three stations; but, during the period from 6 to 12 months, the average daily gain of the Beltsville group was slightly above the standard, the Tifton group averaging 83% of the standard and the Jeanerette group only 42%. The retardation of growth is due in a large part to environmental influences and is pointed out here since it is a factor to be recognized in making comparisons between the Jerseys and Sindhi-Jersey crosses.

The deviations in body weight from the Jersey means for the various crossbred groups are given in Table 1 along with notations of statistical significance. The "t" test for unequal numbers was used in making the

statistical evaulation (Snedecor, 1956). The data from the Jeanerette herd indicate that the 5/8 J and F_1 crosses were heaviest; the Jersey, 3/4 J, F_2 and 1/4 J were intermediate; and the 1/8 J were significantly smaller than the other groups at 6, 12 and 18 months of age. By first lactation the 3/4 J and 1/4 J were very nearly the same weight as the Jerseys; the F_1 group

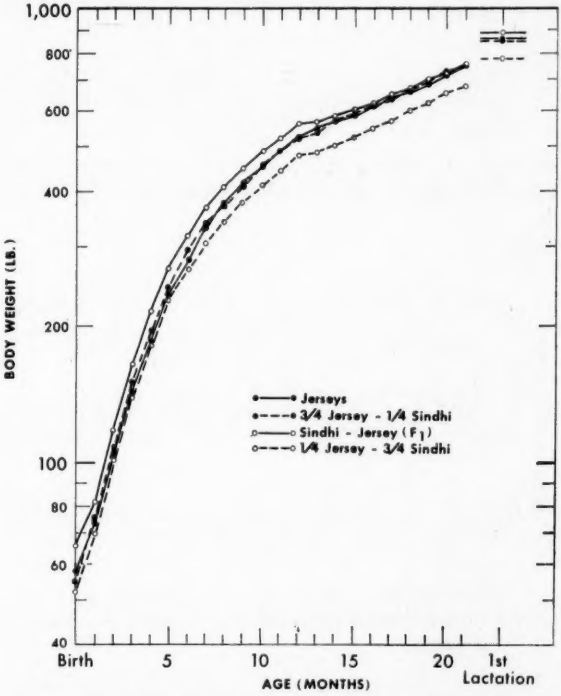

Figure 1. Relationship of body weight to age of Jerseys and Sindhi crosses at Beltsville.

was still heavier but the F_2 group was decidedly lighter than all other groups. At the younger ages the 5/8 J group stands out as being large but the numbers in this group were small and all by one sire; therefore, doubt arises as to this being a true estimate of the 5/8 J combination. Rathore (1949) and Howe (1949) found the mean for the 5/8 J to be midway between the F_1 and 3/4 J. The 1/8 J group was much smaller than the 1/4 J even though they contained theoretically only an additional 12.5% Sindhi. Inbreeding was probably a contributing factor as approximately half of the 1/8 J were 6.25% inbred and the other 12.5%. The group having the lesser degree of inbreeding was about 5% larger.

TABLE 2. MEAN BODY DIMENSIONS OF VARIOUS AGES AND THE DIFFERENCES FROM THE MEANS FOR VARIOUS COMBINATIONS OF RED SINDHIS AND JERSEYS AT BELTSVILLE

Measurement		6 months				12 months			
		Mean Jersey	Difference from Jersey			Mean Jersey	Difference from Jersey		
			3/4 J	F_1	1/4 J		3/4 J	F_1	1/4 J
Height at withers	(cm)	94.7	1.2	3.4**	—1.4	109.4	—0.6	1.2*	—3.3**
Height at hips	(cm)	96.7	1.7**	4.3**	0.5	110.9	0.2	2.1**	—2.2*
Height at pins	(cm)	96.0	0.5	1.6**	—3.6**	109.9	—1.7*	—1.1*	—6.0**
Height at back	(cm)	94.6	0.6	3.1**	—1.3	108.0	—1.0	1.1	—3.4**
Length withers to hips	(cm)	58.0	—0.1	—0.7	—5.1**	70.6	—2.2*	—2.9**	—7.7**
Length hips to pins	(cm)	28.4	—0.1	—0.2	—2.6**	35.3	—1.2*	—2.0**	—4.2**
Total length (withers-hips)	(cm)	86.2	0.2	—0.6	—7.6**	105.8	—3.2**	—4.8**	—11.9**
Length shoulder to pins	(cm)	102.6	0.1	0.4	—6.5**	126.9	—3.1**	—5.0**	—11.7**
Length of loin	(cm)	23.6	—1.5*	—2.6**	—3.9**	27.6	—1.9**	—3.2**	—4.1**
Depth of forechest	(cm)	43.8	0.5	1.5**	—2.3**	54.7	—0.6	0.3	—3.7**
Depth of rearchest	(cm)	44.6	—1.0*	—0.3	—4.3**	54.8	—2.3**	—0.9*	—5.5**
Depth of paunch	(cm)	46.3	—0.6	0.1	—4.2**	55.7	—2.9**	—0.6	—4.7**
Width of forechest	(cm)	23.3	1.1*	2.0**	0.6	30.8	—0.2	0.9*	—0.5
Width of rearchest	(cm)	33.8	1.0	1.0*	—2.0**	43.5	—1.3	0.0	—3.5**
Width of paunch	(cm)	37.5	0.8	0.6	—3.0**	48.7	—3.5**	—1.4	—5.7**
Width of hips	(cm)	27.1	0.2	0.7**	—2.0**	36.3	—1.3**	—0.6*	—3.8**
Width of pins	(cm)	16.4	—0.2	1.3**	0.7*	22.3	—1.0*	0.0	—1.0**
Width of thurls	(cm)	28.1	0.3	0.6**	—1.0**	34.8	—0.6	—1.0**	—2.1**
Width of loin	(cm)	18.7	0.8*	1.9**	0.8**	24.6	0.1	1.7**	0.4
Circ. of forechest	(cm)	112.4	2.2	5.2**	—3.6**	141.6	—1.8	2.9**	—6.7**
Circ. of rearchest	(cm)	129.3	0.2	2.7*	—8.4**	160.6	—4.2*	1.2	—11.8**
Circ. of paunch	(cm)	139.1	1.1*	3.8**	—9.2**	170.2	—6.6*	1.1	—12.8**
Width of forehead	(cm)	13.7	0.8**	1.3**	1.1**	15.4	0.8**	1.4**	1.3**
Width of head at eye level	(cm)	16.4	0.3	0.5**	—0.3	19.1	0.1	—0.1	—0.8**
Length of head	(cm)	33.2	1.5**	3.2**	2.4**	39.6	1.4**	2.3**	2.2**
Circ. of muzzle	(cm)	32.2	—2.7**	—2.8**	—3.8**	37.5	—4.0**	—4.1**	—4.9**
Circ. of shinbone	(cm)	11.9	0.4**	0.8**	0.3	14.1	—0.2	0.2	—0.1
Length of foreleg	(cm)	51.0	0.6*	1.8**	0.8**	55.3	—0.7	0.4	—0.2
Slope of rump	(o)	1.6	3.7**	8.1**	12.2**	2.1	4.9**	8.0**	9.4**
Number of animals		59	23	49	20	52	15	46	23

Measurement		18 months				First lactation			
		Mean Jersey	Difference from Jersey			Mean Jersey	Difference from Jersey		
			3/4 J	F_1	1/4 J		3/4 J	F_1	1/4 J
Height at withers	(cm)	116.8	—1.4	0.7	—3.6**	122.4	—0.3	0.1	—3.5**
Height at hips	(cm)	118.2	0.0	0.6	—3.2**	122.9	—0.4	0.8	—3.1**
Height at pins	(cm)	116.0	—1.8*	—1.9**	—6.3**	120.1	—1.9	—1.9**	—6.4**
Height at back	(cm)	115.0	—0.9	0.2	—4.0**	119.8	—0.6	—0.4	—4.6**
Length withers to hips	(cm)	76.5	—0.5	—3.1**	—8.2**	82.5	—0.3	—2.4**	—6.2**
Length hips to pins	(cm)	39.0	—1.7**	—2.9**	—4.8**	42.6	—1.7*	—3.1**	—6.3**
Total length (withers-hips)	(cm)	115.7	—2.5*	—6.1**	—13.2**	125.1	—2.0	—5.5**	—12.4**
Length shoulder to pins	(cm)	138.6	—2.8*	—6.2**	—12.9**	148.9	—5.9**	—6.3**	—12.9**
Length of loin	(cm)	29.9	—1.4*	—2.8**	—4.2**	33.8	—1.7	—3.5**	—4.0**
Depth of forechest	(cm)	60.5	—1.2*	—0.8	—4.1**	65.4	—1.5	—0.9	—4.8**
Depth of rearchest	(cm)	59.4	—2.3**	—1.5**	—6.0**	65.1	—1.8	—1.7**	—6.7**
Depth of paunch	(cm)	59.8	—2.3**	—1.6**	—4.6**	65.9	—1.3	—1.5*	—7.0**
Width of forechest	(cm)	34.1	0.0	1.1*	—0.3	37.3	—0.5	0.5	—0.1
Width of rearchest	(cm)	47.6	—0.5	—0.7	—4.0**	54.0	—0.2	—1.3*	—4.4**
Width of paunch	(cm)	52.0	—2.3*	—1.8*	—5.8**	60.5	—1.8	—3.3**	—8.1**
Width of hips	(cm)	41.3	—1.3*	—1.1**	—4.6**	47.0	—1.7	—1.6	—5.3**
Width of pins	(cm)	25.9	—1.2*	—0.8	—1.8**	28.7	—1.8	—1.7*	—2.7*
Width of thurls	(cm)	38.3	—0.9*	—1.7**	—3.0**	41.2	—0.8	—1.9**	—3.4**
Width of loin	(cm)	28.1	0.1	1.1**	—0.5**	31.1	0.6	1.1**	—0.7
Circ. of forechest	(cm)	156.0	—1.8	1.1	—7.2**	168.9	—3.4	0.0	—8.1**
Circ. of rearchest	(cm)	174.4	—2.8	—1.5	—13.0**	193.3	—3.6	—3.4**	—14.6**
Circ. of paunch	(cm)	182.1	—4.2	—2.2	—13.4**	204.7	—3.3	—4.5*	—18.9**
Width of forehead	(cm)	16.1	1.2**	1.4**	1.4**	16.7	0.7	1.0**	1.1**
Width of head at eye level	(cm)	20.6	—0.2	—0.5**	—1.1**	21.4	—0.2	—0.6**	—1.3**
Length of head	(cm)	43.1	1.6**	3.0**	2.2**	45.5	2.4**	3.3**	2.1**
Circ. of muzzle	(cm)	40.5	—3.8**	—4.9**	5.4**	41.2	—2.3*	—3.5**	—3.8**
Circ. of shinbone	(cm)	15.2	—0.1	0.0	—0.4*	15.6	—0.2	—0.1	—0.4
Length of foreleg	(cm)	56.5	—0.4	1.2	0.3	57.4	0.8	0.6	0.6
Slope of rump	(o)	3.8	4.7**	6.5**	8.6**	4.6	3.6**	6.5**	9.0**
Number of animals		50	17	44	22	40	7	39	14

* Significant from Jersey mean at the 5% level.
** Significant from Jersey mean at the 1% level.

At Beltsville (table 1) the F_1 group was heavier than the other groups at all ages but significantly so only through 12 months of age. The ¾ J group was significantly heavier than the Jerseys at 6 months but the two groups were very similar while the ¼ J and ⅛ J crosses were lighest at all ages. In the ¾ J, system of mating—whether by Jersey or F_1 crossbred sires—did not appear to affect rate of growth. As in the Jeanerette data, the ⅛ J crosses were smaller than expected and probably for the same reason (average coefficient of inbreeding, 8.9%).

In the Tifton herd the ¾ J and ⅝ J groups were heavier than Jerseys throughout but the differences were not significant until 12 months or later. As in the Jeanerette data, the ⅝ J were above the other groups. This group of ⅝ J also represents rather small numbers and were by one sire. They were, however, produced by a different mating system than those at Jeanerette.

The data in table 1 indicate different patterns of growth between the Jerseys and the crosses in that the crosses gained faster at the early ages. The F_1 crosses were heavier than Jerseys at birth while the other groups were lighter. A further study of data on the Beltsville groups was made to determine the extent that growth patterns were influenced by differences in birth weight. The growth curves for Jerseys, ¾ J, F_1 and ¼ J from birth to 21 months and 3 months after first calving are shown in figure 1. Independent of birth weight, the gains of the F_1 group were significantly greater than all others up to 12 months of age. Thereafter, the rates of gain for the Jerseys, ¾ J and F_1 groups were similar but significantly greater than for the ¼ J. The rates of gain for Jerseys, ¾ J and ¼ J were not significantly different from birth through 6 months but thereafter the ¼ J were significantly smaller than all groups.

The limited number of F_1 crosses kept until maturity averaged slightly heavier (810 lb.) than the Jerseys (795 lb.) at Jeanerette but those at Beltsville were somewhat smaller (1030 lb. vs. 980 lb.).

In general, the crosses gained faster at the earlier ages but only the F_1 and ⅝ J crosses remained larger. Superiority of the F_1 group is in agreement with the report of Rathore (1949) on Red Sindhi-Jersey crosses at the Allahabad Institute in India (the source of the Sindhis brought into the U. S.). Similar observations were made by Littlewood (1934) on Red Sindhi-Ayrshire crosses, by Howe (1949) with F_1 Sahiwal-Jersey crosses in Jamaica and in Zebu-European beef crossing studies reported by Damon (1957).

From the reports available (Joshi and Phillips, 1953; Rathore, 1949; Sundaresan, 1956) it is apparent that the Red Sindhi is a somewhat smaller animal than the Jersey. Females averaged 40 to 45 lb. at birth, 176 lb. at 6 months, 324 lb. at 12 months, 480 lb. at 24 months, 645 lb. at 36 months and 650 to 700 lb. at maturity. These reports are from rather adverse environments by U. S. standards but a small group of females reared at the

Jeanerette station were very nearly the same as those reported in these papers.

If heterosis is defined as deviations from the average of the two parental breeds then there is evidence that some degree of heterosis did occur, at least up to 6 months in all crosses having 75% or less Sindhi inheritance. The F_1 groups, however, are the ones which consistently exceeded the higher parent. Due to the variation in response to the environment and the numbers involved the degree of heterosis in the other combinations is not as clear. It is evident from the Jeanerette data that the Sindhi crosses with 75% or less Sindhi, given the same feeding and management, grew more rapidly than the Jerseys. This is in agreement with earlier data reported by Fletcher *et al.* (1958). There is also some indication of this same trend in the Tifton herd. From these data it appears that under such conditions as may be encountered in the Southern U. S. some Sindhi inheritance affords an advantage in early growth rate. This is in agreement with the findings of Damon (1957) with Brahma-European beef crosses.

Body Dimensions. Tables 2, 3 and 4 give the means for the Jersey groups and the differences from the Jersey means for the crossbred groups. The trend for skeletal growth is very similar to that for weight, in that the crosses tended to excel the Jerseys at the earlier ages but very little of the advantage carried through to first lactation.

The ¾ J, ⅝ J and F_1 groups tended to be taller at withers than Jerseys while the reverse was true with the F_2, ¼ J and ⅛ J (tables 2, 3 and 4). This was somewhat more evident at the younger ages. Indications from the Beltsville data (table 2) are that this same pattern existed in height of back, hips and pins.

In general, the Jerseys were longer in total body length and in both components (withers to hips and hips to pins) than the crosses at all ages. The ⅝ J group at Jeanerette tended to be longer but as pointed out above, this may be due to the sample size. From these data, length appears to be inversely related to the degree of Sindhi inheritance.

The crosses with 50% or less Sindhi showed a slight advantage in depth of forechest at 6 and 12 months but thereafter they appeared to develop less rapidly than the Jersey in all depths. The distance between the ventral surface of the forechest and the ground (length of foreleg) does not appear to have been materially influenced by crossbreeding although the crosses did tend to be a little more "leggy" at the later ages.

The ¾ J and F_1 tended to have slightly greater width of hips at 6 months of age but this shifted to favor the Jerseys at the later ages. Widths of forechest, rearchest, paunch, pins and thurls followed similar patterns.

Circumference of forechest, as expected, followed very closely the pattern for body weights in all groups. The Jeanerette Sindhi-Jersey crosses with more than ¼ Jersey had larger circumference than Jersey at 6, 12 and 18 months, but by first lactation only the F_1's were superior to the Jerseys. The Tifton crossbreds had larger circumference of forechest throughout.

TABLE 3. MEAN BODY DIMENSIONS OF JERSEYS AT VARIOUS AGES AND THE DIFFERENCES FROM THE MEANS FOR VARIOUS COMBINATIONS OF RED SINDHIS AND JERSEYS AT JEANERETTE

Breed group	No.	Height at withers		Length withers to hips		Length hips to pins		Total length		Depth of forechest		Width of hips		Circ. of forechest		Length of foreleg	
		Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.
		(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
6 months																	
Jersey	41	91.7		55.1		27.7		83.1		42.0		25.9		107.2		49.7	
3/4 J	23		—1.3		—1.6		—0.4		—2.3*		—0.2		0.2		1.2		—1.0
5/8 J	5		1.8		—0.1		—1.4		—1.6		1.7		1.8**		6.0		0.1
F_1	28		0.6		—2.5**		—1.3**		—3.8**		1.0*		—0.2		3.5*		0.1
F_2	12		—3.4**		—4.6**		—1.5**		—6.4**		—1.2*		—0.4		0.3		—2.2**
1/4 J	14		—2.3*		—4.8**		—2.8**		—7.8**		—1.2*		—1.2**		—0.1		—1.1
1/8 J	7		—6.8**		—7.0**		—3.7**		—11.0**		—4.5**		—3.3**		—6.5*		—2.3**
12 months																	
Jersey	32	102.0		62.7		32.2		94.8		48.9		31.6		123.6		53.1	
3/4 J	16		0.6		—0.7		1.1*		—0.6		1.7**		1.8**		7.6**		—1.0
5/8 J	5		4.8*		0.3		0.0		1.9		4.1**		3.8**		14.7**		0.7
F_1	35		1.2		—0.3		—1.5**		—1.5		1.4**		—0.1		5.6**		—0.2
F_2	10		—1.1		—2.3		0.0		—4.2**		—1.0		0.6		5.1		—1.1
1/4 J	17		—0.1		—2.8*		—2.8**		—5.5**		0.0		—0.1		6.3**		0.0
1/8 J	4		—8.6**		—10.0**		—5.6**		—15.3**		—4.6**		—4.8**		—5.7		—4.3**
18 months																	
Jersey	31	110.4		70.9		35.6		106.8		54.8		36.7		140.0		55.6	
3/4 J	14		—0.2		—2.2*		2.2**		—1.9		—0.1		1.1		3.2		—0.1
5/8 J	4		4.4*		2.5		—1.1		1.0		3.2*		3.0*		12.0**		3.7**
F_1	48		1.1		—2.4**		—0.8*		—4.0**		—1.5**		—0.6		3.6**		0.5
F_2	11		—2.3		—5.2**		—1.8		—7.4**		—1.2		—0.5		1.4		—1.2
1/4 J	17		—0.4		—3.9**		—3.4**		—7.6**		—1.3		—0.9		2.6		0.9
1/8 J	4		—9.4**		—12.5**		—5.4**		—18.2**		—10.5**		—6.9**		—12.5**		—5.5**
First lactation																	
Jersey	27	120.1		80.0		40.9		121.0		62.6		45.0		159.0		57.5	
3/4 J	10		—2.4*		—1.5		—1.9**		—3.5*		—1.7*		—1.1		—2.4		—0.6
F_1	16		0.1		—3.7**		—2.0**		—5.8**		—0.3		—1.1		3.2		0.3
F_2	7		—6.2**		—9.1**		—4.2**		—12.7**		—5.1**		—3.9**		—7.5*		—1.1
1/4 J	9		—2.2		—5.8**		—3.2**		—9.1**		—2.0*		—2.6**		—1.1		0.9

* Significantly different from Jersey at the 5% level.
** Significantly different from Jersey at the 1% level.

TABLE 4. MEAN BODY DIMENSIONS OF JERSEYS AT VARIOUS AGES AND THE DIFFERENCES FROM THE MEANS FOR 3/4 J CROSSES AT TIFTON

Breed group	No.	Height at withers		Length withers to hips		Length hips to pins		Total length		Depth of forechest		Width of hips		Circ. of forechest		Length of foreleg	
		Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.
		(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
								6 months									
Jersey	78	92.5		56.3		28.7		85.1		44.0		27.5		111.2		49.6	
3/4 J	19		2.7**		—2.2**		—0.1		—2.2**		0.0		—0.7		0.6		1.5*
								12 months									
Jersey	81	106.8		67.7		34.4		102.0		53.3		35.5		134.7		53.7	
3/4 J	21		1.6		—0.8		—0.2		—1.0		1.2*		—0.3		4.5**		—0.1
								18 months									
Jersey	73	113.5		73.0		37.3		110.5		58.3		40.4		148.2		55.3	
3/4 J	11		0.8		—1.0		0.0		—1.2		0.6		—1.5		4.6*		0.1
								First lactation									
Jersey	44	119.5		79.2		41.2		120.4		63.3		45.7		159.8		56.0	
3/4 J	12		0.8		—1.8*		—0.5		—2.2*		0.8		—0.7		4.7**		0.4

* Significantly different from Jersey at the 5% level.
** Significantly different from Jersey at the 1% level.

At Beltsville the F_1 crosses had a larger circumference of forechest than the Jerseys after 12 months but the Jerseys were superior over all crosses in circumference of rearchest and paunch, thus indicating a tendency for developing more "barrel".

Data from the Beltsville herd show that the crosses resembled the Sindhi more than Jerseys in size of head and slope of rump. The crosses had longer heads and greater width of forehead at eye level but smaller muzzles and more slope of rump at all ages. Except at 6 months they had thinner shinbones. The magnitude of the similarity to the Sindhi for these charac-

TABLE 5. TRENDS IN WEIGHTED AVERAGE BODY DIMENSIONS OF SINDHI-JERSEY CROSSBREDS AS COMPARED TO JERSEYS (OBSERVATIONS OF THREE STATIONS COMBINED)

Age	Body weight	Height at withers	Length withers to hips	Length hips to pins	Total length	Depth of forechest	Width of hips	Length of foreleg	Circumference of forechest
				3/4					
6	+	+	—	—	—	0	0	+	+
12	+	+	—	0	—	+	+	0	+
18	+	—	—	—	—	—	—	—	+
1st lact.	—	—	—**	—**	—**	—	—**	+	+
				F_1					
6	+**	+**	—*	—*	—*	+**	+*	+*	+**
12	+	+	—**	—**	—**	+	—	+	+*
18	+	+	—**	—**	—**	—**	—**	+*	+
1st lact.	+**	+	—**	—**	—**	—	—**	+	+
				1/4					
6	—	—*	—**	—**	—**	—**	—*	—	—*
12	—	—*	—**	—**	—**	—**	—**	—	—
18	—	—**	—**	—**	—**	—**	—**	+	—*
1st lact.	—	—**	—**	—**	—**	—**	—**	+	—**

+** difference significantly greater than Jersey (P=.01); +* significantly greater (P=.05); + positive but not significant; 0 less than 0.05%; — negative but not significant; —* significantly less (P=.05); —** significantly less (P=.01).

teristics appears to be directly proportional to the degree of Sindhi inheritance.

The 5/8 J and 1/8 J groups at Jeanerette stand out as being larger and smaller, respectively, than expected but as pointed out in the discussion on body weights, sample size, sire effects and inbreeding may be factors here also.

It is evident that the Jerseys at Jeanerette and Tifton were retarded in skeletal growth as compared to the Jerseys at Beltsville. The degree of variation, however, was not as marked as in the case of body weight. At Jeanerette all groups made a 10-20% change in most body dimensions during each of the three periods, 6-12, 12-18 and 18-first lactation, while in the Beltsville and Tifton herds all groups increased approximately 20% during the 6-12 month period and 8-9% in each of the following periods. Even though the patterns for increased skeletal growth varied among the stations the total increase from 6 months to first lactation was similar for

all stations (about 40%). Station environment appears to have had more effect on the rate of skeletal growth than breed combinations.

Table 5 gives a summary comparison for the three major crossbred groups (¾ J. F_1 and ¼ J) based on a weighted average for the three stations. In general, except for body length, the ¾ J showed some advantages at the early ages, but by first lactation they tended to be a little smaller than the Jerseys. With the exception of a slightly longer foreleg at 18 months and first lactation, the ¼ J were decidedly smaller at all ages in body weight and body dimensions. The differences between the Jerseys and F_1 crosses were very marked at the early ages but except for body length tended to decrease with advancing age.

Limited data on F_1 crosses and Jerseys at maturity in the Jeanerette herd indicate the crosses had a slightly larger circumference or forechest, that they were very similar in height at withers and length of foreleg but were significantly below the Jerseys for body length, depths and widths.

Reports by Rathore (1949), Littlewood (1933) and Howe (1949) studying some of these traits in Zebu-European combinations agree very closely with the results reported here.

These data indicate that the crossing of Red Sindhis with Jerseys has the most effect on body length, size of head and slope of rump. As little as 25% Sindhi inheritance had a distinct effect on most of these measurements.

The crosses tended to have a higher state of condition or fleshing at all ages but it was somewhat more pronounced at the early ages. Therefore, the differences observed in depths, widths and circumference at the early ages may have been to a degree the reflection of the higher state of condition in the crosses rather than actual skeletal differences. The tendency for fatty tissue at the posterior end of the hump, over the hips and pins may also have been a factor in height measurements. Lengths were probably least influenced.

Reports by Rathore (1949) and Joshi and Phillips (1953) on Sindhis in India show that they are somewhat shorter, more compact animals and carry more flesh than European dairy breeds. Rathore also noted that crossbreds with as low as 25% Sindhi had a tendency for the fleshing of Sindhis. The few measurements made on purebred Red Sindhis at Jeanerette indicate they have about the same measurements as the ⅛ J group in table 3.

Although, as in the case of body weight, there are indications of heterosis in skeletal growth, it is not as pronounced as for weight. Crossing the two breeds does seem to have more influence on some skeletal characteristics than others.

The coefficient of variation for both body weight and body dimensions was less in the F_1 groups than the Jerseys but the other groups showed greater variation than the Jerseys. This would suggest that some genetic

TABLE 6. SURFACE AREA AND BODY WEIGHT MEANS OF GROUPS OF FIRST LACTATION PUREBRED JERSEYS AND ¾ J, F_1 AND ¼ J CROSSES FROM BELTSVILLE

Item	Jersey		3/4 J		F_1		1/4 J	
	Value	s.e.[a]	Value	s.e.	Value	s.e.	Value	s.e.
Number of animals	11	.....	6	.....	12	.....	9	.....
Age, mo.	33.4	1.12	33.0	0.93	33.1	0.77	33.2	0.94
Surface area, sq.m.	4.23	0.05	4.13	0.05	4.19	0.03	4.10	0.10
Body weight, lb.	933	19.18	920	20.66	928	22.05	835	42.60

[a] Standard error of the mean.

segregation was possibly taking place in the backcrosses (¾ J. ¼ J) and the F_2 groups.

Surface Area. In previous publications, McDowell *et al.* (1953, 1954) reported that the body surface area of Jerseys and F_1 crossbred cows at Beltsville were very similar. A further study has been made to determine the relationship in other breed combinations of Red Sindhis and Jerseys.

The mean external body surface area of first lactation purebred Jerseys and ¾ J, F_1 and ¼ J crosses from the Beltsville herd are given in table 6. The Jerseys had the largest area, the ¾ J and F_1 were intermediate and the ¼ J had the least. Body weights followed a similar pattern. Using Duncan's multiple range test extended to group means with unequal numbers (Kramer, 1956), the differences between breed groups in surface area and body weights were not statistically significant. These data do not yield evidence that surface area was materially changed in the various combinations of the two breeds.

TABLE 7. SURFACE AREA AND BODY WEIGHT MEANS FOR JERSEY, ¾ J, F_1 AND ¼ J GROUPS OF ALL AGES AT BELTSVILLE AND JERSEYS AND F_1 CROSSES IN THE JEANERETTE HERD

Item	Jersey		3/4 J		F_1		1/4 J	
	Value	s.e.[a]	Value	s.e.	Value	s.e.	Value	s.e.
			Beltsville					
Number of animals	34	.....	10	.....	33	.....	23	.....
Age, mo.	43.3	2.30	31.0	0.68	40.9	2.08	29.2	1.05
Surface area, sq.m.	4.30	0.03	4.04	0.05	4.15	0.05	3.87	0.20
Body weight, in.	984	13.87	888	17.88	942	16.59	772	32.42
Surface area, adj. for age, sq.m.	4.25	.....	4.10	.....	4.31	.....	3.95	.....
Surface areas, adj. for weight at a constant age, sq.m.	4.17	.....	4.08	.....	4.20	.....	4.12	.....
			Jeanerette					
Number of animals	15	.....	.....	.....	15	.....	.....	.....
Age, mo.	56.7	4.79	.....	.....	69.1	2.58	.....	.....
Surface area, sq.m.	3.88	0.05	.....	.....	4.07	0.06	.....	.....
Body weight, lb.	786	18.68	.....	.....	853	23.94	.....	.....
Surface area, adj. for age, sq.m.	3.95	.....	.....	.....	4.00	.....	.....	.....

[a] Standard error of the mean.

To determine the variation in area among the groups over a wider range in weight and age, these groups were pooled with similar breed combinations of other ages, measured in conjunction with climatic laboratory studies (table 7). The trends in surface area and weight were similar to those of the smaller groups. The ¾ J and F_1 groups were again very similar. The ¼ J group was significantly smaller in both weight and area but was also younger than the other groups. Age was found to have a significant correlation to both surface area ($r=0.31$) and weight ($r=0.58$). the relationship was similar in all groups. The group means adjusted for age are shown in table 7. Using Kramer's technique, as mentioned above, (Kramer, 1956) breed effects were significant although the Jersey, ¾ J and F_1 groups were not significantly different from each other nor were the ¾ J, F_1 and ¼ J. In this case, however, the breed effects were not particularly attributable to any one group. The ¼ J crosses showed much the greater variability.

Observations on groups of Jerseys and F_1 crosses from the Jeanerette herd showed the same trend as that of similar groups at Beltsville in that the unadjusted area means were significantly different (table 7). In these data age was also found to have a significant relation to surface area ($r=0.39$). When the area means were adjusted for age the difference between the two breed groups became non-significant.

Although the area means of the Beltsville groups adjusted for age were different, area varied with weight and the relationship appeared to be about the same in all groups. The simple regression coefficients in the unadjusted data range from 0.004 to 0.006 sq.m/kg. If increases in surface area are mainly associated with increases in weight then the difference in surface area between groups may be due to weight. The group means adjusted for weight, independent of age, are given in table 7. After this adjustment the differences between means becomes non-significant.

From the trends in these data there are indications that total body surface declined with increasing percentage of Sindhi but was offset by heterosis in the F_1 crosses. It appears, however, that the differences in the surface area of animals of approximately the same age would be small. It would seem that even though the Sindhi had a marked effect on the phenotypic characteristics of the crosses in such things as dewlap, navel fold, hump, size of ears and head, which would give the appearance of increased surface area, this was offset by other changes, such as length.

Summary

Data from three stations are presented on comparative body weights, body dimensions and the external surface area of purebred Jerseys and various combinations of Red Sindhis and Jerseys.

In general the crosses gained faster than Jerseys up to 12 months of age but only the F_1 and ⅝ Jersey crosses remained larger at 18 months

and first lactation. All crosses having 75% or less Sindhi inheritance showed some degree of heterosis for weight gain up to 6 months but the F_1 groups were the only ones which consistently exceeded the higher parent. Due to variation in response to the environment and the numbers involved, the degree of heterosis in the other combinations was not as evident.

The trend of skeletal growth was very similar to that for weight in that the crosses tended to excel the Jerseys at the earlier ages but very little of the advantage carried through to the first lactation. There were indications of heterosis in skeletal growth but it was not as pronounced as for weight. Crossing of the two breeds appeared to have the greatest effect on body length, size of head, slope of rump and fleshing. As little as 25% Sindhi inheritance had a distinct effect on these measurements.

Indications were that crossing the breeds had a small effect on total body surface area. It is evident that although the Sindhi had a marked effect on certain phenotypic characteristics in the crosses; namely, the dewlap, navel fold, hump, size of ears and head, that would give the appearance of greater surface area, these were largely offset by a more compact body.

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LYSINE AND METHIONINE SUPPLEMENTATION OF CORN-SOYBEAN OIL MEAL RATIONS FOR PIGS IN DRYLOT[1]

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A CORN-SOYBEAN oil meal ration fortified with vitamins, antibiotics and minerals has been used at this station in the recent research on protein requirements of growing-finishing swine. Such a ration contains sufficient tryptophan but is deficient in lysine and methionine for optimum swine growth, according to average analytical values and the reported requirements for these amino acids (Shelton *et al.*, 1951a, 1951b; Brinegar *et al.*, 1950; Germann *et al.*, 1958).

The level of these amino acids in the ration is apparently not the only consideration. The quantitative requirement for them is influenced by protein level, as well as by the amount of cystine, vitamin B_{12} and choline in the ration (Grau, 1948; Almquist, 1947, 1952; Becker *et al.*, 1955; Jackson and Block, 1932; Salmon, 1947; Patrick, 1952; Oginsky, 1950; Bennett, 1950; Dyer *et al.*, 1949).

Whitehair and Hillier (1952) observed a small growth response and improvement in feed efficiency from adding 0.2% DL-lysine to a 14% all plant ration. Further work at the same station (Whitehair and MacVicar, 1952), with similar rations supplemented with 0.2% DL-lysine, indicated a marked improvement in both rate of gain and feed efficiency. In the same experiments, 0.2% supplemental DL-methionine improved feed efficiency markedly and rate of gain slightly.

From the work of Totter and Berg (1939), Kratzer (1950) and Bauer and Berg (1943) it has been generally accepted that only the L form of lysine is utilized for growth in swine, but that both the D and L forms of methionine are utilized.

The experiment herein reported was conducted to determine whether well-fortified corn-soybean oil meal rations containing 12% or 14% protein could be improved by various levels of added lysine and/or methionine.

Procedure

In each of two replicates, 32 ration treatments were assigned at random to 32 lots of two pigs each. The 32 treatments consisted of a 2 x 4 x 4

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factorial arrangement of two levels of protein, four levels of L-lysine and four levels of DL-methionine. The first replicate was conducted in the fall and winter and the second replicate the following spring and summer.

Although the calculated deficiencies of lysine and methionine differed between the 12% and 14% basal rations, the same levels of the supplemental amino acids were used at both protein levels in this experiment. Since this was a feeding trial to determine whether supplemental lysine and/or methionine would be beneficial in 12% and 14% rations, and not an experiment specifically to determine the lysine and methionine requirements of swine, setting these arbitrary supplemental levels seemed desir-

TABLE 1. PERCENTAGE COMPOSITION OF THE BASAL RATIONS

Ingredients	Ration protein [a]	
	12%	14%
Ground yellow corn (9.8% protein)	90.6	85.4
Solv. soybean oilmeal (47.3% protein)	5.7	11.0
Dicalcium phosphate	0.9	0.8
Ground limestone	1.2	1.2
Salt, iodized	0.5	0.5
Vitamin premix [b]	1.0	1.0
Trace mineral premix [c]	0.1	0.1

[a] The 12% protein basal ration assayed 0.35% lysine and 0.19% methionine. The 14% protein basal ration assayed 0.41% lysine and 0.21% methionine.

[b] Contributed the following per pound of 12% protein complete ration: Vitamin A, 700 i.u.; vitamin D_2, 400 i.u.; riboflavin, 1.0 mg.; niacin, 11.5 mg.; calcium pantothenate, 3.8 mg.; choline, 185 mg.; vitamin B_{12}, 5.0 mcg.; and oxytetracycline, 5.0 mg. Supplied the same for the 14% protein ration except for the following: Vitamin A, 900 i.u. calcium pantothenate, 3.4 mg. and choline; 125 mg.

[c] Contributed the following in mg. per pound of complete ration: Fe, 31.8; Cu, 2.2; Co, 0.7; Zn, 2.1; Mn, 26.8.

able. Previous growth studies with other species (Russell *et al.*, 1951; De Bey *et al.*, 1952; Anderson and Combs, 1951) indicate a growth depression resulting from the addition of lysine or methionine in excess of requirements. Therefore, the maximum supplemental levels were set no higher than the calculated deficiency of each amino acid.

The basal rations and their calculated lysine and methionine content along with the assay values obtained from selected experimental rations are presented in table 1.

Thirty-two crossbred gilts and 32 crossbred barrows (Poland China x Landrace x Duroc) averaging 22.8 lb. body weight and 42.2 days of age were selected according to uniformity in breeding and condition for each replicate. Each pig, within sex group, was randomly assigned to a lot within the replicate. The pigs were wormed with 0.5% sodium fluoride added to their feed for 2 days and were sprayed with benzene hexachloride before going on experiment. Feed was provided *ad libitum* and the pigs were hand-watered three times daily. The pigs were weighed individually and the feed was weighed back every two weeks. Each pig was removed from the experi-

TABLE 2. SUMMARY OF AVERAGE DAILY GAINS (lb.)

Percent DL-methionine added	Percent L-lysine added				
	0	0.05	0.10	0.15	Average
	12 percent protein ration				
0	1.02	1.24	1.06	1.15	1.12
0.025	1.02	1.10	1.30	1.23	1.16
0.050	1.06	0.99	1.17	1.16	1.10
0.075	1.17	1.10	1.31	1.16	1.19
Average	1.07	1.11	1.21	1.18[a]	1.14
	14 percent protein ration				
0	1.42	1.43	1.16	1.11	1.28
0.025	1.30	1.31	1.38	1.28	1.32
0.050	1.41	1.34	1.32	1.49	1.39
0.075	1.31	1.41	1.13	1.41	1.32
Average	1.36	1.37	1.25	1.32	1.32[b]

[a] Protein x lysine interaction and linear effect of lysine level within 12% rations significant at P=0.05 or less.
[b] Average effect of protein level significant at P=0.01 or less.

ment at 100±5 lb. body weight. For the first replicate, conducted in the fall and winter, artificial heat was provided.

Results and Discussion

The average daily gains and feed efficiency data are summarized in tables 2 and 3. All statements concerning statistical significance are made at a probability level of 0.05 (or less) unless otherwise indicated. Pigs

TABLE 3. SUMMARY OF POUNDS OF FEED REQUIRED PER HUNDRED POUNDS OF GAIN

Percent DL-methionine added	Percent L-lysine added				
	0	0.05	0.10	0.15	Average
	12 percent protein ration				
0	354	331	319	302	326
0.025	372	312	297	287	317
0.050	417	336	297	286	334
0.075	355	310	292	384	335
Average	374	322	301	314[a]	328
	14 percent protein ration				
0	286	269	290	291	284
0.025	288	268	270	310	285
0.050	285	276	268	266	273
0.075	292	278	277	247	273
Average	287	272	277	278	279[b]

[a] Protein x lysine interaction and quadratic effect of lysine level within 12% rations significant at P=0.05 or less.
[b] Average effect of protein level significant at P=0.01 or less.

fed the 14% protein rations gained significantly faster (1.32 vs. 1.14 lb. per day) on significantly less feed (279 vs. 328 lb. per 100 lb. gain), on the average, than those on 12% protein. Daily feed consumption per pig on each level of protein averaged 3.64 lb.

Lysine. Rate of gain and feed efficiency on the 12% protein ration increased as level of lysine supplementation increased to the 0.10% supplemental level, then levelled off or declined (tables 2 and 3). Statistical analysis of the data within the 12% protein level showed a significant linear effect of rate of gain and a quadratic effect of feed efficiency on levels of lysine. Jensen (1953) reported a linear increase in rate of gain and feed efficiency when a similar 12% ration was supplemented with 0.03 to 0.09% L-lysine in the form of DL-lysine monohydrochloride.

As the level of lysine was increased in the 14% protein ration, growth rate and feed efficiency were not consistently affected. This protein level $\times$ lysine interaction was statistically significant, resulting in a definite improvement in rate of gain and feed conversion on the 12% level of protein but little or no effect on the 14% level.

The lack of growth and feed efficiency response to supplemental lysine in the 14% protein ration supports much recent work (Henson *et al.*, 1954; Becker *et al.*, 1954; Meade, 1956a). In each of these cases the basal rations contained 0.60% lysine or more. Other research (Meade and Teter, 1956; Meade, 1956b) has indicated no improvement in nitrogen balance with lysine supplementation of similar rations. Hutchinson *et al.* (1956), using a basal ration with 14.25% protein and only 0.525% lysine, also reported no response to supplemental DL-lysine.

Feed consumption showed a linear decrease ($P<.05$) as increased levels of lysine were added to the 14% protein rations. A similar pattern, although not statistically significant, was observed for the 12% rations. These observations, supported by the data in tables 2 and 3, suggest that palatability of the supplemental lysine may be an important factor in influencing gains or feed conversion. Along with these observations that higher levels of lysine may depress feed intake, one should note the feed conversion by pigs fed the lower levels of supplemental lysine (table 3). In each of the comparisons, 0.05% supplemental lysine improved feed conversion and except for one comparison in the 14% protein group the 0.1% supplemental level improved feed conversion. These observations certainly suggest that lysine is limiting at both protein levels even though the average effect of supplemental lysine was not statistically significant.

Methionine. Response to methionine supplementation of the 14% ration (tables 2 and 3) indicates a trend, not statistically significant, toward increased growth rate and feed efficiency up to the 0.05% supplemental level.

Methionine supplementation of the 12% rations exerted no effect on rate of gain or feed efficiency. These results are in general agreement with those of Sewell and Keen (1958) who reported no growth response

from supplementing 14, 17 and 20% protein corn-soybean meal-peanut meal rations with DL-methionine.

Summary

Corn-soybean oil meal rations containing 12% and 14% protein were supplemented with four levels of L-lysine and/or four levels of DL-methionine and, in a 2 x 4 x 4 factorial arrangement of treatments, fed to pigs weighing 23 lb. until they reached a weight of 100 lb. The 32 ration treatments were imposed on pens of two pigs, one barrow and one gilt, in each of two replicates.

On the 12% protein ration, rate of gain and feed efficiency were improved by L-lysine, up to the 0.10% supplemental level. Lysine supplementation of the 14% protein ration exerted no consistent effect. The protein level × supplemental lysine interaction was statistically significant for both rate of gain and feed conversion.

Methionine supplementation of the 12% ration exerted no apparent effect on either gains or feed conversion. Methionine supplementation of the 14% ration gave indication of improvement in rate of gain and feed efficiency, up to the 0.05% supplemental level; however, differences were not statistically significant.

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THE LYSINE REQUIREMENT OF WEANLING SWINE AT TWO LEVELS OF DIETARY PROTEIN

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Mertz *et al.* (1949) initially demonstrated that lysine was an essential amino acid for growth and development of the weanling pig. They reported that deficiency symptoms which included cessation of growth, retarded and depraved appetite, rough hair coat, and emaciation, were alleviated when 2.0% DL-lysine HCl was added to the diet. Brinegar *et al.* (1950) concluded that the lysine needs of weanling pigs fed 10.6 and 22.0% protein were 0.6 and 1.2% of the diet or 5.7 and 5.5% of the protein, respectively. With a diet containing 23.8% protein primarily from zein and gelatin, Shelton *et al.* (1951) observed that the weanling pig required between 0.8 and 1.0% lysine.

Some workers have used practical diets to study the lysine need. Catron *et al.* (1953) reported that pigs fed a corn-soybean oil meal diet containing 12% protein responded favorably to a 0.10% L-lysine addition; whereas, at 14% protein, lysine was without supplementary value. According to average analyses, 12 and 14% protein diets composed of corn and soybean oil meal should contain 0.52 and 0.66% lysine, respectively. Also, Meade (1956) has noted that an addition of L-lysine failed to improve nitrogen retention of pigs fed a corn-soybean oil meal diet containing 15.9% protein and 0.69% lysine.

Recently, Hutchinson *et al.* (1957) found that the weanling pig fed a semi-purified ration containing 11.69% protein and 1362 metabolizable calories per pound needs 0.52% lysine for optimum growth. Germann *et al.* (1958) observed that the lysine requirement of the 25-pound pig fed 13.4% protein was 0.70% of the moisture-free diet or 4.7% of the protein.

Although the isoleucine need of the weanling pig increases as the dietary protein increases (Becker *et al.*, 1957) it is not a fixed percentage of the dietary protein as has been suggested for lysine by Brinegar *et al.* (1950). The purpose of the present study was to determine the lysine need of the weanling pig when fed two levels of dietary protein.

Experimental

Three experiments were conducted with weanling pigs weighing approximately 30 lb. initially. Prior to the start of the tests, these pigs had been

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fed diets believed to be adequate in all known nutrients. Composition and amino acid content of the experimental diets are shown in table 1. The ratios of one amino acid to another in diet A and diet B were identical.

Experiments 1 and 2 were conducted each with 40 crossbred pigs, and Experiment 3 with 20 crossbred pigs. In each of the experiments, outcome groups of five pigs each were formed on the basis of ancestry, weight and

TABLE 1. PERCENTAGE COMPOSITION OF DIETS

Diet designation	A	B
Ingredients		
Corn starch	53.4	34.33
Sesame seed meal	27.0	46.00
Dextrose	10.0	10.00
Woodflock	2.0	2.00
Crude corn oil	3.0	3.00
Mineral mixture #2[a]	4.0	4.00
Vitamin A & D oil (3000A-600D)	0.5	0.50
L-histidine HCl	0.1	0.17
Vitamin mixture #26[b]	+	+
Aureomycin (25 mg./lb.)	+	+
	100.0	100.00
Composition		
Crude protein (N x 6.25)	12.78	21.71
Arginine	1.20	2.02
Histidine	0.27	0.46
Isoleucine	0.62	1.05
Lysine[c]	0.33	0.57
Leucine	0.97	1.65
Methionine	0.40	0.68
Cystine	0.17	0.29
Threonine	0.46	0.79
Tryptophan	0.25	0.42
Valine	0.66	1.12
Phenylalanine	1.07	1.83
Tyrosine	0.56	0.95

[a] Becker and Terrill (1954).
[b] Becker, Ullrey and Terrill (1954).
[c] Determined by assay according to the method of Henderson and Snell (1948).

general condition. The pigs were allotted to the levels of lysine at random from the outcome groups and the outcome groups were allotted at random to the two rations or protein levels. In Experiment 3 only the higher level of protein was fed.

Pigs were randomly assigned to feeding cages and individually fed for a 28-day period. Individual weight gains and feed consumption were recorded weekly. Feed and water were supplied *ad libitum*. Growth rate and feed efficiency were used as criteria to determine maximum response.

All lysine substitutions were made at the expense of dextrose. L-lysine was added as L-lysine monohydrochloride.

Results

Results of the three experiments are presented in table 2. Performance on the unsupplemented diets of Experiment 1 was very

TABLE 2. RESPONSE OF WEANLING PIGS FED VARIOUS LEVELS OF LYSINE

Level of lysine added, %[a]	0	0.1	0.2	0.3	0.4	0.5	0.6
Diet A—12.8% protein							
Lysine level							
% of diet	0.33	0.43	0.53	0.63	0.73	0.83	0.93
% of protein	2.58	3.36	4.14	4.92	5.70	6.48	7.26
Experiment 1—Av. initial wt., 29.9 lb.							
Av. daily gain, lb.	0.23	0.35	0.79	1.04	1.27	—	—
Av. daily feed per pig, lb.	2.07	1.94	2.79	2.87	3.36	—	—
Av. gain-feed ratio	0.11	0.18	0.28	0.36	0.38	—	—
Experiment 2—Av. initial wt., 31.9 lb.							
Av. daily gain, lb.	—	—	1.13	1.44	1.50	1.45	1.51
Av. daily feed per pig, lb.	—	—	3.01	3.47	3.35	3.38	3.53
Av. gain-feed ratio	—	—	0.38	0.42	0.45	0.43	0.43
Diet B—21.7% protein							
Lysine level							
% of diet	0.57	0.67	0.77	0.87	0.97	1.07	1.17
% of protein	2.63	3.09	3.55	4.01	4.47	4.93	5.39
Experiment 1—Av. initial wt., 33.7 lb.							
Av. daily gain, lb.	0.50	0.58	0.95	1.19	1.32	—	—
Av. daily feed per pig, lb.	2.48	2.63	3.10	3.42	3.44	—	—
Av. gain-feed ratio	0.20	0.22	0.31	0.35	0.38	—	—
Experiment 2—Av. initial wt., 29.5 lb.							
Av. daily gain, lb.	—	—	1.05	1.08	1.29	1.37	1.52
Av. daily feed per pig, lb.	—	—	2.89	2.82	2.92	3.04	3.37
Av. gain-feed ratio	—	—	0.36	0.38	0.44	0.45	0.45
Experiment 3—Av. initial wt., 30.8 lb.							
Av. daily gain, lb.	—	—	0.82	1.21	1.41	1.51	1.53
Av. daily feed per pig, lb.	—	—	2.05	2.77	2.71	2.84	3.05
Av. gain feed ratio	—	—	0.40	0.44	0.52	0.50	0.50

[a] Four pigs per treatment.

erratic. On diet A and to a lesser extent on diet B, the pigs exhibited anorexia, rough hair coat, depressed growth and a low gain-feed ratio. Similar symptoms were reported by Mertz *et al.* (1949). The pigs on diet B, which received a higher protein level and a higher lysine level, gained at a slightly greater rate than the pigs on diet A. There was also some improvement in gain-feed ratio, but still the pigs on diet B showed deficiency symptoms.

The control diets in Experiment 1 were increasingly improved as increments of lysine were added. However, it was not clear whether maximal growth was attained on either diet, since the response to lysine levels did not plateau. The pigs responded to dietary lysine levels up to and including 0.73% in the 12.8% protein diet and 0.97% in the 21.7% protein diet. These maximal levels of lysine correspond to 5.70 and 4.47% of the protein for the 12.8 and 21.7% protein diets, respectively. However, it was felt that the highest lysine level was near the requirement, since it supported very satisfactory performance.

TABLE 3. ANALYSES OF VARIANCE OF AVERAGE DAILY GAIN, DAILY FEED INTAKE, AND GAIN-FEED RATIO

Source of variance	df	Mean square		
		Daily gain	Feed intake	Gain-feed ratio
		Experiment 1		
Protein level (P)	1	0.3010	1.6933	0.0081
Group within P (G)	6	0.0855*	0.7464**	0.0035*
Lysine level (L)	4	1.3027**	2.0792**	0.0785**
P x L	4	0.0142	0.1080	0.0034
G x L	24	0.0310	0.1920	0.0013
		Experiment 2		
Protein level (P)	1	0.2059	1.1526	0.0002
Group within P (G)	6	0.0891	0.7072*	0.0024
Lysine level (L)	4	0.2147*	0.2610	0.0094**
P x L	4	0.0392	0.0914	0.0011
G x L	24	0.0639	0.2277	0.0011
		Experiment 3		
Lysine level (L)	4	0.3439**	0.6315*	0.0112*
Outcome groups (G)	3	0.0345	0.0707	0.0011
L x G	12	0.0361	0.1303	0.0033

* Significant at 5% level.
** Significant at 1% level.

Analyses of variance of the data for average daily gain, average daily feed intake and gain-feed ratio in Experiment 1 are shown in table 3. Levels of lysine produced a highly significant ($P<0.01$) difference in average daily gains. Outcome groups within protein levels showed a significant difference ($P<0.05$) indicating that the method of grouping was helpful in eliminating variability from the treatment comparisons. No interaction between protein level and lysine level was noted. The difference in average daily feed for lysine levels and for outcome groups within lysine levels was highly significant ($P<0.01$). Gain-feed ratios were significantly different for the lysine levels ($P<0.01$) and for the outcome groups ($P<0.05$).

Since the results of Experiment 1 failed to indicate whether maximum performance had been obtained at the highest level of lysine, Experiments 2 and 3 were conducted to evaluate higher levels of supplemental lysine.

In Experiment 2 the levels of lysine at intervals of 0.1% ranged from 0.53 to 0.93% and from 0.77 to 1.17% on the low- and high-protein diets, respectively. Lysine levels produced differences in average daily gains, and groups within protein levels produced differences in feed intake, which were statistically significant ($P<0.05$). Gain-feed ratios were significantly ($P<0.01$) different for the lysine levels. In terms of all criteria, perform-

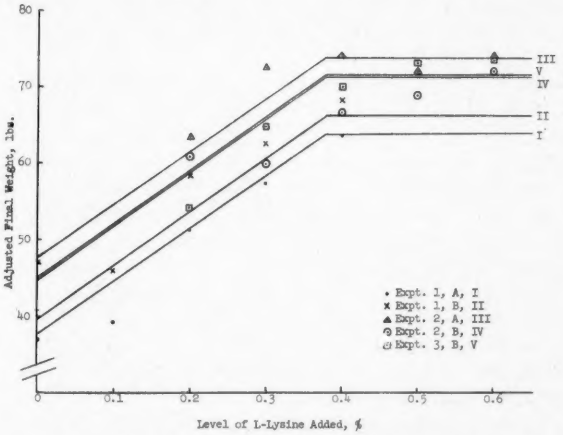

Figure 1. Relation of final weight (adjusted to equal initial weight) to lycine level.

ance appeared to plateau at about 0.73% lysine on the low-protein diet. On the high-protein ration, daily gains increased as lysine increased, but the values for gain-feed ratio appeared to level off at 0.97% lysine.

Experiment 3 was conducted to obtain further information on the response to lysine levels in the high-protein diet. In this trial lysine levels produced a highly significant ($P<0.01$) difference in average daily gain and a significant ($P<0.05$) difference in gain-feed ratio.

To ascertain the lysine requirement, regression lines rising linearly at the lower levels and becoming horizontal at the requirement were fitted by least squares with adjustment for differences in initial weight. The several sets of data were homogeneous as to the indicated value of the requirement; that is, "parallel" lines fitted the data satisfactorily (figure 1). The minimum lysine level for maximum growth, that is, the lysine requirement, was 0.38% additional lysine, which corresponds to 0.71 and 0.95% lysine in the diet, or 5.55 and 4.38% of the protein, in diets A and B, respectively. The fitted lines are presented in figure 1.

Discussion

In the studies presented here it has been found that pigs fed a semi-purified diet containing sesame seed meal and L-histidine to provide 12.8 and 21.7% protein required lysine at 0.71 and 0.95% of the diet or 5.55 and 4.38% of the dietary protein, respectively. Assuming a linear relationship between the dietary protein and the lysine requirement, expressed as a percentage of the protein, the lysine need within the dietary protein range studied may be expressed by the equation $Y=7.23-0.131\chi$, where Y is the lysine need and χ is the percent dietary protein. Hence, the lysine and isoleucine requirements of the weanling pig have been found to vary in similar fashion with the dietary protein level (Becker *et al.*, 1957).

It is noteworthy that the influence of added dietary protein upon the lysine and isoleucine requirements appears similar in magnitude. The lysine need, expressed as a percent of the protein, decreased 1.81% (of its value of 7.23 at zero percent protein) per unit increase in percent protein; whereas, the isoleucine need (Becker *et al.*, 1957) decreases correspondingly at the rate of 1.69%. It seems logical that this value may be similar for all the essential amino acids, except possibly arginine.

A noticeable difference exists between our data and those of Brinegar *et al.* (1950). They found that pigs fed a diet containing 10.6% protein from linseed meal supplemented with methionine and histidine required 0.6% lysine. However, when a 22% protein diet composed primarily of sesame seed meal or wheat, zein, and meat and bone scrap was fed, the maximum gains resulted at 1.2% lysine. If the values were expressed as a percent of the protein, the difference could be largely eliminated as the lysine need was 5.7 and 5.5% of the 10.6 and 22.0% protein diets, respectively. Our data show that the lysine need, expressed as a percent of the protein, decreases considerably as the level of protein increases. Perhaps the fact that 10.6% protein was inadequate to support normal performance in the study by Brinegar *et al.* (1950) explains the variation in findings. When the pig gains presented in our report were adjusted for differences in initial weight, protein levels failed to produce differences, hence the different lysine requirements at the two protein levels must be explained on some other basis.

A very interesting observation pertains to the failure of a higher dietary level of a deficient protein to overcome its amino acid deficiency for the pig. Sesame seed meal supplemented with histidine fed at 12.8% protein supported a suboptimal rate of gain during the test. A 70% increase either in the level of sesame seed meal plus histidine or in the level of lysine failed substantially to improve the rate and efficiency of gain. The unsupplemented diets A and B provided about 46 and 60%, respectively, of the dietary lysine required by the pig; so, it appears very difficult to incorporate sufficient sesame seed meal into the diet in order to overcome its lysine deficiency. Again, the results reported by Becker *et al.*

(1957) show that blood flour also fails to overcome its deficiency of isoleucine when fed at a higher level of the diet. Of course, the authors recognize that higher dietary levels of an amino acid deficient protein will overcome the deficiency, if the protein is only slightly deficient.

The reported values for lysine need of the weanling pig do not show general agreement. However, this seems reasonable since previous studies have been conducted with limited animals and with diets that were quite variable in protein and caloric density.

Theoretically the caloric density of the diet should influence the amino acid requirement. As the caloric density decreases, the diet is consumed in increasing quantities, so that the amino acids required in the diet would also decrease. Amino acid needs should be a constant percent of the available energy. In this report diets A and B were calculated to contain 83 and 80% total digestible nutrients. Hence, the lysine need was 0.86 and 1.19% of the total digestible nutrients in diets A and B, respectively.

Using the equation to express the protein effect and assuming the lysine need is the same per unit of total digestible nutrients, it is possible to calculate the lysine need at variable protein and caloric densities. For instance, weanling pigs fed practical rations containing 16% protein and 75% total digestible nutrients are calculated to require 0.75% lysine in the diet. Similar calculations for a 12% protein diet containing 75% total digestible nutrients suggest a need of 0.61% lysine; a value that agrees with the finding of Catron *et al.* (1953) who reported that pigs fed a corn-soybean diet containing 12% protein responded favorably to 0.1% supplemental lysine. According to average analysis, a 12% protein diet primarily of corn and soybean oil meal should contain 0.52% lysine and thus it would require about 0.1% lysine for adequacy.

Summary

Weanling pigs weighing about 30 lb. were individually fed semi-purified diets containing either 12.8 or 21.7% protein to determine the response to varied levels of lysine. The source of protein was sesame seed meal supplemented with L-histidine. Supplementary lysine was added as L-lysine monohydrochloride.

The rate of gain at the two levels of protein was similar, but the lysine requirement varied with the level of protein fed. At 12.8% protein the pig required 0.71% lysine in the diet or 5.55% of the dietary protein; and, at 21.7% protein the lysine need was 0.95% of the diet or 4.38% of the dietary protein. Assuming a linear relationship between dietary protein and lysine need, expressed as a percentage of the protein, the need within the protein range studied may be expressed by the equation, $Y=7.23-0.131\chi$, where Y is the lysine need and χ is the percent of dietary protein.

Expressed as a percent of the total digestible nutrients, the lysine required in the low- and high-protein diets was 0.86 and 1.19%, respectively.

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EFFECT OF SODIUM FLUORIDE AND HYGROMYCIN ON GROWING-FINISHING PIGS [1]

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LARGE intestinal roundworms, commonly known as ascarids, cost hog raisers of the United States an estimated 50 million dollars a year (Spindler, 1956). These losses are due largely to unthriftiness and can be avoided to a large extent with good management and treatment. Schwartz (1952) listed sodium fluoride as the most generally satisfactory treatment for the removal of ascarids from swine. This worker also reported a reduction in feed consumption when rations containing sodium fluoride were fed.

Recently it has been reported that the anthelmintic hygromycin is effective in the control of internal parasites of swine and that it also affects growth rate of growing pigs (Conrad and Beeson, 1957, 1958; Rutledge and Teague, 1958; Thrasher *et al.*, 1958).

The objectives of this study were to determine (1) the effect of the anthelmintic sodium fluoride on subsequent performance of growing pigs, (2) the role of hygromycin alone or in combination with chlortetracycline in complete mixed rations for pigs on concrete drylot, and (3) the effect of hygromycin in complete mixed rations and in protein supplements fed to growing-finishing pigs on pasture.

Experimental

Trial 1. One hundred twenty weanling pigs of Duroc, Hampshire and Poland China breeding were divided into 20 lots of 6 pigs each, formed according to litter and weight. Five ration treatments were employed with four lots receiving each of the ration treatments. The additions to the basal ration were: None, 15 gm. of chlortetracycline per ton, 12 gm. of hygromycin B [3] per ton, a combination of the above levels of chlortetracycline and hygromycin B, and 12 gm. of hygromycin B to an average weight of 100 lb. In addition, two of the four lots on each of these treatments were wormed with 0.5% of sodium fluoride for 48 hours previous to the beginning of the trial.

The basal ration was composed of ground yellow corn, solvent soybean oil meal, 60% digester tankage, steamed bonemeal, trace mineralized salt, and a vitamin supplement which contributed the following per lb. of

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[3] Supplied as "Hygromix", which contained 2.4 gm. hygromycin B per lb.

ration: 1 mg. riboflavin, 2 mg. calcium pantothenate, 4.5 mg. niacin, 5 mg. choline and 4.5 mg. of vitamin B_{12}. The ration was calculated to contain 15.5% crude protein initially and was adjusted to contain 12% protein when the pigs averaged approximately 100 lb. liveweight.

All pigs were housed in a building with concrete-floored pens and had access to outside concrete lots. Feed and water were provided *ad libitum*. Live weights were recorded at two-week intervals and feed consumption records were maintained.

Fecal samples were obtained at the termination of the trial and ascarid ova counts were determined according to a flotation procedure (Benbrook and Sloss, 1948). All pigs were wormed with sodium fluoride at this time and observations were made for expelled roundworms.

Trial 2. Eighty-five weanling pigs of Duroc, Hampshire, Poland China and Spotted Poland China breeding were used in this trial. They were divided into five groups of 17 pigs each on the basis of litter, weight and sex. Each group was placed in a two-acre alfalfa-brome-grass pasture. Lots 1 and 2 received the same basal ration as was fed in trial 1 while Lots 3, 4 and 5 were fed free-choice grain and protein supplement. Shelled corn was the grain for Lots 3 and 4, and corn and oats (60:40) for Lot 5. Hygromycin B was added to the ration fed to Lot 2 at a level of 12 gm. per ton and to the protein supplement fed to Lots 4 and 5 at a level of 60 gm. per ton. Data on rate of gain, feed efficiency and ascarid ova counts were collected as in trial 1.

Results and Discussion

Trial 1. A summary of the average performance data is presented in table 1. The rate of gain, feed efficiency, and feed consumption data were analyzed by analysis of variance as described by Snedecor (1946). A highly significant difference in rate of gain due to ration treatment was found for the early growth period. Pigs receiving hygromycin showed a slightly greater increase in gains than those receiving chlortetracycline. However, when the two additives were combined a synergistic effect was produced. This was true for all lots of pigs, both wormed and unwormed, that received this treatment. Although there was no significant difference due to previous worming treatment, it was noted that the unwormed pigs gained faster than the corresponding lots that had been wormed with sodium fluoride previous to the experiment. Sodium fluoride treated pigs gained an average of 0.23 lb. and the untreated pigs gained 0.71 lb. during this treatment period. It appears that the setback incurred may not have been completely overcome during the period from 40 to 100 lb.

Difference in gains due to ration treatment was statistically significant for the period from approximately 100 to 200 lb. The wormed pigs that received hygromycin during this growth phase gained significantly slower than the controls. Those pigs that were fed the combination of chlortetracycline and hygromycin gained significantly less than the lots fed

TABLE 1. INFLUENCE OF HYGROMYCIN ALONE AND IN COMBINATION WITH CHLORTETRACYCLINE ON PERFORMANCE OF GROWING PIGS

Item	Control	Chlortetracycline, 15 gm.	Hygromycin, 12 gm.	Chlortetracycline, 15 gm. Hygromycin, 12 gm.	Hygromycin, 12 gm., to 100 lb.
Wormed[a]					
Number of pigs[b]	12	12	12	12	12
Av. initial wt., lb.	40.6	40.8	40.7	40.6	40.7
Av. final wt., lb.	197.5	195.5[c]	193.5	200.2	194.6
Av. daily gain, lb.					
40–100 lb.[d]	1.36	1.44	1.58	1.67	1.57
100–200 lb.[e]	1.97	2.02	1.75	1.82	1.84
40–200 lb.[f]	1.69	1.76	1.64	1.76	1.73
Average daily feed, lb.					
40–100 lb.	4.10	4.25	4.04	4.46	4.57
100–200 lb.	7.16	7.21	6.42	6.12	6.76
40–200 lb.	5.74	5.87	5.42	5.44	5.84
Feed per 100 lb. gain, lb.					
40–100 lb.	300	294	256	268	291
100–200 lb.	364	357	367	336	365
40–200 lb.	339	334	332	310	336
Unwormed					
Number of pigs[b]	12	12	12	12	12
Av. initial wt., lb.	41.6	41.9	41.9	41.9	42.1
Av. final wt., lb.	195.5	202.2	201.4	205.9	199.2
Av. daily gain, lb.					
40–100 lb.[d]	1.50	1.58	1.60	1.83	1.61
100–200 lb.[e]	1.89	2.21	1.92	2.02	1.91
40–200 lb.[f]	1.71	1.92	1.79	1.94	1.78
Av. daily feed, lb.					
40–100 lb.	4.47	4.50	4.38	4.99	4.58
100–200 lb.	7.33	7.49	7.12	7.32	6.94
40–200 lb.	6.08	6.12	5.97	6.34	5.94
Feed per 100 lb. gain, lb.					
40–100 lb.	298	285	274	273	283
100–200 lb.	389	340	371	360	363
40–200 lb.	354	319	334	326	333

[a] Wormed with 0.5% sodium fluoride in feed for 48 hours before the experiment.
[b] Two lots of six pigs each.
[c] A calculated final weight included for one pig that died from causes not due to experimental treatment.
[d] L.S.D. at $P<0.05=0.18$ and at $P<0.01=0.24$.
[e] L.S.D. at $P<0.05=0.18$ and at $P<0.01=0.23$.
[f] L.S.D. at $P<0.05=0.15$ and at $P<0.01=0.20$.

chlortetracycline alone. These results are in agreement with those of Conrad and Beeson (1958) who also reported a lower gain when hygromycin was fed during this growth period. Removing the hygromycin from the ration when the pigs weighed 100 lb. resulted in a slight but insignificant

increase in gain when compared to the group which received hygromycin during this period. There was no reduction in gains when hygromycin was fed to the unwormed pigs. However, as in the case of the wormed pigs, the lots fed chlortetracycline and hygromycin gained significantly less than the lots fed chlortetracycline alone. All of the lots in this group of unwormed pigs gained at nearly the same rate except for the chlortetracycline lot which gained significantly faster than the other lots.

When the data are combined for the entire growing period a significant response was obtained only in the lots of unwormed pigs fed chlortetracycline or a combination of chlortetracycline and hygromycin. However, the analysis of variance indicates a significant difference in rate of gain between wormed and unwormed pigs. The average daily gain for the two

TABLE 2. ASCARID OVA PER GRAM OF FECES OF PIGS FED HYGROMYCIN ALONE AND IN COMBINATION WITH CHLORTETRACYCLINE

Treatment	Control	Chlortetracycline, 15 gm.	Hygromycin, 12 gm.	Chlortetracycline, 15 gm. Hygromycin, 12 gm.	Hygromycin, 12 gm., to 100 lb.
Wormed[a]	10	265	0	0	155
Unwormed	590	410	0	0	10
Average	300	338	0	0	83

[a] Wormed with 0.5% sodium fluoride in feed for 48 hours before the experiment.

groups was 1.72 lb. for the wormed pigs and 1.83 lb. for the unwormed pigs. Some swine producers have claimed that sodium fluoride retards gain of pigs while others have stated that their treated pigs gain quite satisfactorily. The above data would support both statements in that the sodium fluoride pigs did gain significantly slower than the untreated pigs, although their gain of 1.72 lb. per day would be considered satisfactory by most swine husbandmen.

The differences in average daily feed consumption were not significant. However, the pigs fed hygromycin had the lowest daily feed intake during the period from 100 to 200 lb. liveweight. Conrad and Beeson (1958), Meade *et al.* (1958) and Thrasher *et al.* (1958) also reported that the addition of hygromycin depressed feed intake. Meade reasoned that this may have been due to a lack of ration palatability.

Analysis of the data on feed required per unit of gain showed a significant difference during the period of 40 to 100 lb. and the 40 to 200 lb. period. In all cases the control pigs required more feed than those fed the antibiotic additions. There was no difference in feed requirements of the wormed or unwormed pigs.

The feeding of hygromycin or hygromycin and chlortetracycline for the entire growing-finishing period gave complete control of ascarids as

shown in table 2. Removing the hygromycin from the ration when the pigs weighed about 100 lb. resulted in complete freedom from ascarids at 200 lb. in most but not all pigs. Teague *et al.* (1958) reported a marked but not complete reduction in ascarid ova in the feces of pigs fed hygromycin for 49 days. This would lend support to the above data in which the pigs were on the treated ration for an average of 38 days.

Trial 2. The results of trial 2 are summarized in table 3. The addition of hygromycin did not affect the gains on either method of feeding. The difference in gains (7%) in favor of pigs fed the complete mixed ration over free choice appproached statistical significance at the 5% level.

TABLE 3. THE EFFECT OF HYGROMYCIN ON GROWING PIGS FED ON PASTURE

Ration designation	Mixed		Free choice[a]		
Lot number	1	2	3	4	5
Addition	None	Hygromycin[b]	None	Hygromycin[c]	Hygromycin[c]
Number of pigs	17	17	17	17	17
Av. initial wt., lb.	33.0	33.0	33.1	33.0	33.1
Av. final wt., lb.	196.1	192.9	183.4	182.7	189.2
Av. daily gain, lb.	1.55	1.51	1.40	1.41	1.46
Av. daily feed, lb.	4.92	4.74	4.51	4.59	5.17
Feed per 100 lb. gain, lb.	317	314	322	324	354
Ascarid ova per gm. of feces	1473	0	530	0	0

[a] Lots 3 and 4 were fed free-choice shelled corn and protein supplement and lot 5 received a ground mixture of 60 parts corn to 40 parts oats as the cereal grain and the same protein supplement as lots 3 and 4.
[b] 12 gm. per ton of feed.
[c] 60 gm. per ton of protein supplement.

Hygromycin appeared to reduce feed consumption as had been noted in trial 1. When complete mixed rations were fed this reduction was about 3.7% (lot 1 compared to lot 2). The pigs in Lot 4 which were fed hygromycin in their protein supplement consumed 13.5% less supplement than Lot 3; however, they consumed about 5% more corn so that their total feed consumption was slightly higher than for Lot 3. The pigs in Lot 5 consumed 22% more grain and 25% less supplement than Lot 3. Similar differences in supplement and grain consumption have been reported by Wahlstrom (1959) when a corn-oats mixture was compared to corn alone as cereal grains for pigs on pasture. Feed required per unit of gain was greatest for the pigs fed the corn-oats mixture free-choice with only small variations between the other lots.

Fecal samples were obtained from the pigs at the termination of the trial as in trial 1 and ascarid ova were determined on these samples. Ascarid ova were completely absent from the feces of those pigs fed hygromycin either in the complete mixed feed or in the protein supplement. The absence of ova from the feces of these pigs was not due to chance

as the pigs in Lots 1 and 3, which did not receive hygromycin, had from 270 to 3860 ova per gram of feces.

The data reported in this paper may be considered to be in disagreement with early work on the harmful effects of swine ascarids (Francioni and Morris, 1930; Spindler, 1937). Certainly there was no relationship between the number of ascarid ova in the feces and the rate of gain or feed efficiency of the pigs in these trials. However, the ascarid infestation may not have been great enough to cause any harmful effects. Therefore it seems advisable to continue to recommend treatment for swine ascarids as these parasites can multiply so rapidly that a heavy infestation could soon be present if no treatment were used.

Summary

One hundred and twenty weanling pigs were fed in drylot in trial 1 to determine the effects of sodium fluoride, hygromycin, chlortetracycline, or a combination of hygromycin and chlortetracycline on pig performance and ascarid control. In trial 2 eighty-five pigs were used to study the effectiveness of hygromycin in complete mixed and free-choice rations fed on pasture.

The daily gains of pigs fed hygromycin or chlortetracycline in drylot rations were increased during the period from weaning to 100 lb. and a synergistic effect was produced when both were fed. During the later growth phase (100 to 200 lb.) the greatest growth response was obtained when pigs were fed chlortetracycline alone. Hygromycin appeared to reduce feed consumption and in some cases rate of gain during this period.

Hygromycin had no effect on the rate or efficiency of gains of pigs fed complete mixed or free-choice rations on pasture. Again, a decrease in consumption of the hygromycin-containing feed was noted.

Effective control of swine ascarids was obtained by feeding hygromycin either in a complete mixed ration or in a protein supplement. Removing the hygromycin from the ration when pigs weighed 100 lb. did not give complete freedom from ascarids at market time. However, the number of ascarid ova present in the feces at this time was markedly decreased.

Treating weanling pigs for roundworms by feeding 0.5% sodium fluoride in the feed for 2 days caused a significant reduction in weight gains during the treatment period; also, the untreated pigs gained about 7% faster from weaning to market weight.

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EFFECT OF PELLETING ON THE CHEMICAL COMPOSITION AND DIGESTIBILITY OF ALFALFA MEAL

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PELLETING of diets for ruminants has received rather widespread interest in recent years and a number of experimental feeding trials have been conducted in which pelleted feeds have been compared with those in the whole or ground forms. However, published data on the effects of pelleting on the chemical composition and digestibility of the various nutrients in ruminant diets are rather limited.

Bell *et al.* (1955) reported that pelleting of two diets, composed of corn and ground alfalfa hay or dehydrated alfalfa meal, increased the digestibility of ether extract and decreased the digestibility of crude fiber by lambs when compared with the same diets in the unpelleted state. Lindahl and Davis (1955) also reported that pelleting tended to increase the digestibility of ether extract and decrease the digestibility of crude fiber in seven digestion trials with lambs. The increase in the digestibility of ether extract was significant in three of the trials and the decrease in the digestibility of crude fiber was significant in two of the trials. Changes in the digestibility of other constituents, with pelleting, were minor and were not significant.

Blaxter and Graham (1956) found that grinding and pelleting of chopped dried grass, fed at two levels of intake, resulted in a reduction of digestibility of all constituents with the exception of the ether extract. The average digestibility of the ether extract was considerably higher in three out of four of the trials, but the standard errors of the means were also rather high and the increases in digestibility were not significant.

Long *et al.* (1955) using lambs as the experimental animal compared the digestibility of a diet composed of prairie hay, alfalfa hay, corn, cottonseed meal, and molasses in the natural, ground, and pelleted states. Grinding the whole diet lowered its digestibility and pelleting the ground diet restored the digestibility to approximately the same level as observed in the whole diet. The digestibility of organic matter, crude protein, and crude fiber were significantly higher ($P<0.01$) in the pelleted diet than in the ground diet and, although not stated by these workers, an inspection of their tabular data indicates that the digestibility of ether extract was also significantly higher ($P<0.05$) in the pelleted diet than in either the whole or ground diets. However, Esplin *et al.* (1957) found no significant

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differences in apparent digestibility between pelleted and unpelleted diets in four digestion trials with lambs.

As a review of the literature indicated that the ether extract portion of roughage containing diets might be affected by pelleting, this experiment was designed to provide additional data on the effect of pelleting on chemical composition and digestibility with special attention to the ether extract fraction. Alfalfa meal was used as the test diet and studies were conducted on three physical states; original meal, pelleted meal, and reground pelleted meal.

Experimental Procedure

Dehydrated alfalfa meal containing no added animal fat was mixed in an upright mixer to assure uniformity; two-thirds of the meal was pelleted through a 3/8 inch die with the use of steam and one-half of the pellets were reground in a hammer mill to the fineness of the original meal.

Six, two-year-old crossbred wethers were assigned at random to the columns of two 3 x 3 orthogonal Latin squares. Experimental diets were assigned at random to treatments, and consecutive periods in time were assigned to rows. Each period consisted of a 10-day preliminary period followed by a 10-day collection period.

The sheep were kept in metabolism cages which permitted freedom of movement and which had raised screen bottoms. Feed allowances were calculated on the basis of 120% of maintenance (Brody, 1945). The daily feed allowance was fed in two equal amounts and a small amount of water was mixed into the meal and ground pellets to reduce dustiness. Water was kept before the sheep at all times. Total fecal collections were made daily during the collection periods using waterproof canvas bags. One-half of the daily feces output was taken as an aliquot, dried for 24 hours under forced draft at 75° C, and composited for the 10-day period. Composite samples of each diet were made from daily samples during the collection periods.

Feed and feces samples, ground to pass through a 20-mesh screen, were analyzed for proximate constituents by the use of regular procedures (AOAC, 1955). Moisture was determined by use of a vacuum oven. Ether extract was determined using a soxhlet apparatus and the extracted ether soluble material was dried and weighed. Gross energy was determined by means of an adiabatic bomb calorimeter using the customary correction for nitrogen and sulfur.

Results and Discussion

The chemical composition of the diets is given in table 1. The high crude protein and low crude fiber contents indicate high quality of the dehydrated alfalfa meal used in this study.

It may be seen that the pelleting process resulted in a definite increase

in the ether extract content of both the pellets and ground pellets. This observation substantiates previous work in this laboratory with diets containing alfalfa products (Lindahl and Davis, 1955, 1955a). Although it has been demonstrated that a small amount of grease used for lubricating the rollers of pellet mills can contaminate the pellets (Lee, 1956), special precautions were taken to keep this contamination to a minimum during the processing of the test materials in the present experiment. That the observed increase in the ether extract resulted from the pelleting process *per se* rather than from contamination with grease or oil is demonstrated by the gross energy values for the three physical states of the alfalfa meal. The average absolute increase in the ether extract resulting from pelleting was 1.13%. If this increase had resulted from contamination with the high energy content lubricating grease the gross energy value of

TABLE 1. CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS[a]

Constituent	Alfalfa	Pellets	Ground pellets
	%	%	%
Crude protein	22.25	22.19	22.08
Ether extract	2.55	3.67	3.69
Crude fiber	22.34	21.64	21.78
Nitrogen-free extract	38.21	38.09	37.81
Gross energy (Kcal. per gram)	4.28	4.29	4.29

[a] All values are on the moisture free basis.

the pelleted alfalfa meal would have had to increase by approximately 0.07 Kcal. instead of the observed increase of 0.01 Kcal. The lack of difference in the gross energy values also indicates that the increase in ether extract resulted largely from non-fat ether soluble materials. Work is currently in progress in this laboratory to determine what changes occur in the composition of the ether extract fraction of alfalfa meal during the pelleting process. However, part of the observed increase in ether extract content is probably due to cellular rupture during the pelleting process which allows for greater penetration of ether during the extraction procedure.

A slight decrease in crude fiber content also was observed in the pelleted meal. Similar results have been observed in previous studies (Lindahl and Davis, 1955a) where the crude fiber content of pelleted diets has varied from 90.5 to 99.4% of that of the unpelleted diet. The reduction in crude fiber content, although variable in degree, has been consistent and must be associated with the pelleting process. As the determination of crude fiber is quite empirical and the results vary with particle size and length of time that the cellular materials are in contact with the acid and alkali during the determination, the reduction in crude fiber content with pelleting probably results from rupture of certain cellular structures during the pelleting process.

The apparent digestion coefficients are given in table 2. An analysis of variance of the digestion coefficients using a method outlined by Federer

TABLE 2. APPARENT DIGESTION COEFFICIENTS

Constituent	Alfalfa meal	Pellets	Ground pellets
	%	%	%
Dry matter	60.7 (0.4)[a]	61.4 (0.5)	61.3 (0.5)
Crude protein	63.2 (1.3)	63.7 (0.5)	63.9 (0.5)
Ether extract	41.8 (2.6)	59.4 (1.0)	59.8 (0.6)
Crude fiber	44.2 (0.8)	43.8 (0.7)	43.4 (0.8)
NFE	75.7 (0.1)	75.1 (0.5)	74.9 (0.7)
Gross energy	60.4 (0.4)	60.8 (0.5)	61.3 (1.0)

[a] The figure in parenthesis is the standard deviation of the mean.

(1957), which permits an estimation of carry-over effects, is presented in table 3.

Pelleting the alfalfa meal resulted in a highly significant increase in the digestibility of the ether extract ($P<0.01$) but pelleting of the alfalfa meal, or grinding the pellets into meal had no effect on the digestibility of dry matter, crude protein, crude fiber, NFE, or gross energy. The increase in the digestibility of the ether extract apparently resulted from the increased ether extract in the diets which had been pelleted as the average percentage of ether extract in the feces of the sheep when on the meal, pellets, and ground pellets was 3.7, 3.8, and 3.8%, respectively.

The similarity of the digestion coefficient for the pellets and ground pellets also indicate that any changes in digestibility resulted from the pelleting process rather than from the physical state of the material.

The statistical analysis given in table 3 permits the estimation of the presence of carry-over effects, that is, the effect of any given treatment on the subsequent treatment, which is a possible source of error in digestion trials performed with Latin square designs. The results of the analyses indicates that there were no carry-over effects from one period to another. There also were no significant period, square, or animal effects, nor were there any significant interactions between them.

The calculated TDN content of the meal, pellets, and ground pellets was 55.4, 57.1, and 56.9%, respectively. The slightly greater TDN of the

TABLE 3. ANALYSIS OF VARIANCE OF THE DIGESTION COEFFICIENTS

		Mean square					
Source of variation	D.F.	Dry matter	Crude protein	Ether extract	Crude fiber	NFE	Gross energy
Squares	1	0.4901	0.0621	0.0544	2.7848	0.0003	2.3618
Periods	2	1.8640	0.1377	8.2610	29.5896	0.2261	4.7988
Sheep within a square	4	0.5802	5.5009	7.6348	23.5382	1.5617	1.3987
Period X square	2	0.8320	6.5840	10.5394	23.4218	0.6622	1.1722
Residual (eliminating direct effects)	2	0.6552	2.7008	3.9814	33.4724	1.7188	2.1803
Direct (eliminating residual effects)	2	0.1828	1.9665	506.8294**	15.5935	4.6726	0.2750
Error	4	2.1279	2.8949	6.0402	12.3436	6.3886	3.0950

** $P<0.01$.

pellets and ground pellets was due to the increased digestible ether extract, which contributed 4.7, 8.6, and 8.7%, of the total TDN of the meal, pellets, and ground pellets, respectively. This, however, is an artifact of the accepted procedure for calculating TDN of roughages in which ether extract is given a weight 2.25 times greater than that assigned to crude protein or the carbohydrate fractions. That there was no difference in the digestibility of the energy of the meal and its pellets is illustrated by lack of any difference in digestibility of the gross energy.

Several workers have reported increased rates of gain and/or increased feed efficiency when lamb fattening diets were pelleted (Neale, 1953; Bell *et al.*, 1954; Thomas *et al.*, 1955; Cate *et al.*, 1955; Neale, 1955; Esplin *et al.*, 1957). The results of the present and of a number of previously conducted digestion trials indicate that changes in digestibility resulting from pelleting of ground diets are relatively minor and it is difficult to explain the increased feedlot performance on the basis of changes in digestibility of the major dietary constituents. A subsequent paper will deal with comparisons of the utilization of nutrients in whole and pelleted roughages.

Increased productivity from pellet feeding could result from an increase in the retention of digested nutrients, a reduction in feed wastage, an increase in rate of digestion and an increase in feed consumption, better utilization of nutrients resulting from a balanced intake of roughage and concentrates or from a combination of these factors. The results of Blaxter and Graham (1956) indicated that the retention of energy by sheep consuming pellets was not significantly higher than that from chopped hay at normal ranges of feeding and Esplin *et al.* (1957) also postulated that beneficial results from pelleting is probably due to improved palatability or from a more exact control of the concentrate roughage ration rather than from an increase in the nutritive value. Additional experimental work on the above factors would be highly desirable.

Summary

The digestibility of dehydrated alfalfa meal fed as meal, as pellets, and as pellets reground to the fineness of the original meal was determined with sheep at Beltsville, Maryland.

Pelleting the alfalfa meal resulted in a consistent increase in the percentage of the ether extract fraction as determined by regular analytical procedures but had no effect on the gross energy content. Pelleting or regrinding the pellets had no apparent effect on the digestibility of dry matter, crude fiber, crude protein, NFE, or gross energy. However, there was a highly significant increase in the apparent digestibility of the ether extract fraction of the pellets and ground pellets. The observed increase in digestibility of the ether extract appeared to result from the increase in the apparent ether extract content of the pelleted diets, as the ether extract content of the feces was similar on the three diets.

Statistical analyses were used to estimate the carry-over effects, i.e., the effect of a given treatment on the digestibility of nutrients in the subsequent trials. No significant carry over effects were observed.

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A STUDY OF THE VARIATIONS OF MYOGLOBIN CONCENTRATION IN "TWO-TONED" HAMS [1]

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THE factors associated with pork quality have not been clearly defined but are thought to include fat distribution, relative amounts of lean and fat tissues, flavor, tenderness, juiciness and color. The ideal color of fresh pork has been described as greyish-pink but deviations from this standard are very common in retail cuts. While the color of pork has little or no effect on its nutritive properties, the degree of pigmentation and pigment variation within cuts has a significant effect on their general appearance and may affect the ease with which they are merchandized, either as fresh or cured products.

A contrast in pigmentation between two adjacent muscles, or "two-toning", is particularly apparent when it occurs between the *longissimus dorsi* and the *psoas major* of the loin and between muscles within the ham. This study was undertaken to determine the amount of the red pigment, myoglobin, present in certain muscles of hams from hogs of known origin and to investigate some of the factors responsible for the variations observed.

Experimental

Samples for this study were obtained from hogs used in an experiment at the University of Minnesota. The experiment was one of a number at the Minnesota Agricultural Experiment Station designed to determine the effect of antibiotics and other feed supplements on the rate and economy of gain and carcass characteristics.

In the experimental design, 64 weanling pigs were paired on the basis of litter and sex and allotted by pairs to lots 1 and 2. Lot 1 received a basal ration; the ration of Lot 2 was supplemented with 2.5 lb. of an antibiotic preparation per ton of feed. This supplement provided 10 gm. of chlortetracycline hydrochloride per ton of feed. A 14% protein ration was fed from weaning to 125 lb. This was reduced to 11% from 125 lb. to a slaughter weight of 210 to 225 lb. The basal feed mixture for each feeding period is shown in table 1.

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TABLE 1. COMPOSITION OF BASAL FEED MIXTURE

Ingredient	Fed from— Weaning to 125 lb.	125 lb. to slaughter
Ground corn, lb.	802	885
Soybean meal, lb.	82	28
Tankage, lb.	36	12
Linseed meal, lb.	18	6
Alfalfa meal (dehydrated), lb.	50	50
Steamed bone meal, lb.	7	14
Trace mineralized salt, lb.	5	5
Fortafeed 2–49C,[a] lb.	0.5	0.5
Total	1000	1000
Vitamin B_{12}	5 mg.	5 mg.

[a] Vitamin supplement.

The pigs were taken off feed 12 hours prior to shipping to a meat packing plant for slaughter. The carcasses were chilled, certain carcass measurements were taken and a one-inch thick center slice was removed from the right ham of each carcass. These samples were frozen and shipped to the American Meat Institute Foundation in Chicago. The remaining ham from each carcass was cured and processed in the plant and held for evaluation at the completion of the experiment.

Muscles in the center slice of ham showing the maximum contrast in color were selected for myoglobin determinations. The *rectus femoris, vastus lateralis, vastus intermedius* and *vastus medialis* were pooled in a ground sample and are referred to as the dark muscles. The *biceps femoris* was selected as the lightest muscle in the slice. The anatomical location of the muscles is shown in figure 1.

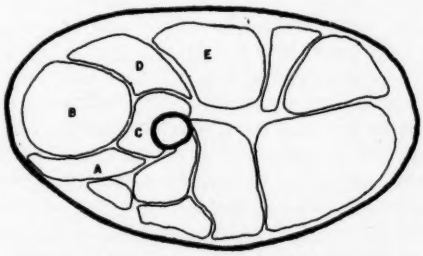

Figure 1. Anatomical location of muscles used for myoglobin analysis.

Dark Muscles
A—Vastus Medialis
B—Rectus Femoris
C—Vastus Intermedius
D—Vastus Lateralis

Light Muscle
E—Biceps Femoris

The quantitative determination of myoglobin was made by Morgan's (1936) modification of Theorell's procedure for the isolation of myoglobin (1932). The myoglobin was converted to cyanomyoglobin following the procedure described by Drabkin and Austin (1935–36) for hemoglobin. A 10-gm. sample of ground muscle was minced in a Waring Blendor for one minute with one volume of water. After standing overnight in a refrigerator the sample was centrifuged and the red supernatant brought to pH 7.0 with 1 N sodium hydroxide. Foreign proteins were precipitated by the addition of 0.25 volume of saturated basic lead acetate followed by centrifugation. The resulting supernatant was brought to pH 6.6 and the phosphate concentration to 3 M by the addition of mono- and dibasic

TABLE 2. SUMMARY OF CARCASS CHARACTERISTICS AND MYOGLOBIN CONCENTRATION IN HAMS FROM CONTROL AND ANTIBIOTIC SUPPLEMENTED HOGS

Item	Control	Supplemented
Number of animals	32	32
Chilled dressed wt., ab., lb.	153.4	154.4
Dressing percentage, av.	74.3	74.6
Backfat thickness, av., cm.	4.82	4.83
Days on exp., av.	122.5**	115.5
Myoglobin, mg./gm.		
Light muscles, av.	1.18±0.16	1.21±0.15
Dark muscles, av.	1.83±0.40***	1.93±0.39***

** Statistically significant at P=.01.
*** Difference between means for myoglobin content of light and dark muscles statistically significant at P=.001.

potassium phosphate in the solid form. Usually 2.56 gm. of KH_2PO_4 and 2.8 gm. of K_2HPO_4 per 10 ml. of solution provided the above concentrations. Following centrifugation potassium ferricyanide and sodium cyanide were added to the supernatant to final concentrations of 0.6 mM and 0.8 mM respectively. This provided a relatively stable solution which, after appropriate dilution, was read at 540 mμ in a Coleman Junior Spectrophotometer. For purposes of calculations, a millimolar extinction coefficient of 11.5, equivalent to that of cyanomethemoglobin (Drabkin and Austin, 1935–36) and a molecular weight of 16,500 for myoglobin were assumed. Repeated extraction of samples indicated approximately equal distribution of myoglobin in supernatants and residues in the first extraction and this was applied in calculating the mg. of myoglobin per gm. of fresh tissue. A similar procedure has been used in studies reported previously (Ginger *et al.*, 1954).

Results

As indicated in table 2, the dressed weight, dressing percentage and backfat thickness for the supplemented and control lots were very similar.

The faster gains of the litter mates on antibiotic supplementation are indicated by the significantly fewer days required to reach slaughter weight.

The average myoglobin concentrations in the *biceps femoris* of the control and antibiotic supplemented lots were 1.18 and 1.21 mg. per gm. respectively. The group of four dark muscles from the ham slices of both the control and supplemented groups contained significantly more myoglobin than the *biceps femoris*. As indicated for the light muscles, the dark muscles from the supplemented lot contained slightly more myoglobin (1.93 mg./gm.) than the control lot (1.83 mg./gm.) but in neither case were the differences significant.

Inspection of the data suggested a relationship between breeds and the amount of myoglobin in the muscles. Table 3 summarizes the myoglobin

TABLE 3. FEEDING PERIOD AND MYOGLOBIN CONCENTRATIONS IN HAMS FROM HOGS OF CERTAIN BREEDING

Item	Breed		
	Poland China	Duroc	Chester White
Number per lot	16	28	20
Days on exp., av.	12.12	108.12	126.80
Myoglobin, mg./gm.			
Light muscles, av.	1.20±0.17	1.24±0.10	1.14±0.14
Dark muscles, av.	2.35±0.22***	1.80±0.30***	1.58±0.20***

*** Difference between means for myoglobin content of light and dark muscles statistically significant at P=.001.

content of ham muscles from the three breeds of hogs represented in this study. For each of the breeds, there was significantly less myoglobin in the *biceps femoris* than in the group of four dark muscles.

The contrast between the light and dark muscles, or the degree of "two-toning", was most marked in the Poland China breed, in which the dark muscles contained almost twice as much myoglobin as the *biceps femoris*. The least degree of "two-toning" was observed in the Chester White breed in which the dark muscles contained only one-third more pigment than the *biceps femoris*. The hams from the Durocs contained an average of 1.24 mg. of myoglobin per gm. in the *biceps* and 1.80 mg. per gm. in the darker muscles, and were intermediate in the degree of "two-toning". These analyses confirmed subjective evaluations of the ham slices prior to extraction. It is of particular interest to note the similarity between the myoglobin concentrations in the light muscles and the magnitude of the differences between the pigment concentrations in the dark muscles of the three breeds. A statistical analysis of these data indicated that the differences in the myoglobin concentration between breeds were significant at the 5% confidence level for the dark muscles only. This would indicate that the ham slices from the Poland China breed had a

more pronounced "two-toning" because of the high level of myoglobin in the dark muscles rather than a low level of myoglobin in the *biceps femoris*. This is contrary to the commonly held opinion that "two-toning" results when certain muscles are deficient in pigment. While the differences between means for the light muscle are not statistically significant it may be seen that ham slices from the Chester White breed which had the least pigment in the *biceps* were also the most uniform in pigment content.

Cured hams from 11 of the 32 pairs of litter mates were available for observation at the conclusion of the experiment. These were evaluated subjectively by a panel of judges and were found to follow the same general pattern of pigment variation as indicated by the chemical analysis. Those who observed the fresh and cured hams were of the opinion that the degree of "two-toning" was reduced somewhat by curing and heat processing.

Discussion

A number of factors are known to influence the color of carcass tissues. The earlier observations by Hammond (1932) and McMeekan (1940) were largely subjective and no compensation was made for the effect of pH on color. As suggested by Lawrie (1950), and further indicated by the research of Briskey *et al.* (1958), it is possible to draw erroneous conclusions regarding the effect of environmental and nutritional factors on the pigment content of meat carcasses when subjective evaluations are employed. Investigations at the Danish Meat Research Institute (1958) have indicated that meat color is due to the interaction between pigment content and "transparency" of the meat fibers. They have shown that poor transparency is normally associated with a pale color but that a high pigment concentration may compensate for poor transparency resulting in a greater apparent redness or pigment content in the meat.

In some experiments, particularly those involving the application of stress immediately prior to slaughter, the visible color may be of greater interest than the actual pigment concentration. In other research, as described here, the quantity of pigment is of primary concern. Lawrie (1940) found significant differences between the myoglobin content of the heart, *longissimus dorsi,* diaphragm and *psoas major* muscles of the pig. He demonstrated further that the muscles of normally active pigs had a higher level of muscle myoglobin than relatively immobile pigs. From these studies and other observations, it was concluded that activity was the fundamental factor responsible for controlling the amount of pigment found in any muscle. The effect of age on myoglobin concentration has been shown by a number of workers (Hammond, 1932; Lawrie, 1950; Biorck, 1949). Iron deficiency anemia also reduces the muscle myoglobin concentration. This is particularly evident in milk fed veal calves (Hammond, 1932; Neidermeier, 1955).

The present data suggest one additional factor which influences pigment concentration in carcass meats. The results indicate that the amount of pigment or, more particularly, the degree of pigment "two-toning" or the predisposition toward these characteristics is quite highly heritable. While this study shows that the pigment variations are between breeds it is recognized that the differences may be within breeds as well. An expansion of the present data is required to draw further conclusions. Pigment distribution in the muscles of carcasses may become an important "quality" factor to consider in selecting animals for breeding programs in the future.

The acceptance of hams at the retail level is thought to be influenced by the degree and uniformity of color. Unacceptable color of sliced ham may result from undercuring, bacterial growth after heat processing, light fading, or variations in pigment concentration. Proper curing methods, adequate processing and proper packaging and display of cured meats can greatly reduce losses due to the first of these factors, but are of limited value when variations in pigmentation are pronounced. Recognition of pigment variation of the type described must be made when evaluating "faded" or "discolored" cured pork.

Summary

In the study presented, certain muscles from center ham slices from 32 litter-mate pairs of hogs fed on a control and Aureomycin-supplemented ration were analyzed for myoglobin content. The results showed no effect of this supplementation on the myoglobin content of either the *biceps femoris* or a composite sample of the *rectus femoris, vastus lateralis, vastus intermedius* and *vastus medialis*. The three breeds of hogs represented in the study showed distinct differences in the myoglobin content of the latter four dark muscles. For the samples studied, the degree of "two-toning" was more closely related to the amount of myoglobin in the dark muscles than the amount of myoglobin in the light colored *biceps femoris*. The data suggest that the concentration of myoglobin and the degree of "two-toning" in hams are heritable characteristics. The method for determining myoglobin is decribed.

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SOME LUMBAR LEAN MEASURES AS RELATED TO SWINE CARCASS CUT-OUTS AND LOIN EYE AREA [1]

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RESULTS of swine carcass contests have shown that visual evaluation of pork carcasses is difficult, and that placings made on intact carcasses often fail to conform with carcass cut-outs. Thus, other visual carcass characteristics besides length, backfat thickness and conformation are needed to aid in appraisal of the intact carcass. The certified meat hog programs being sponsored by various swine breed associations and swine testing stations make use of cut-outs on the live or carcass basis and loin eye area in evaluation procedures. However, such evaluation procedures require cutting of the carcass, which is not feasible where carcasses are graded and sold to jobbers or manufacturers. Under the Canadian system of carcass rail grading, some experienced graders have indicated that the appearance of the exposed lumbar muscles in combination with other visual measurements can be used in arriving at the carcass grade. Thus, this study was undertaken to investigate the usefulness of some rapid measurements of the exposed lumbar lean and to determine their relationships with carcass cut-outs and loin eye area.

Materials and Methods

The hog carcasses in this study were all from hogs slaughtered at the Michigan State University abbatoir during a period from the spring of 1956 to the fall of 1958. Since all measurements were not taken on the first 142 carcasses, a second group of 150 carcasses was added. The two groups will be reported as separate experiments for ease of discussion. Backfat thickness, carcass length and area of the loin eye were determined according to the procedure of Strong (1951) for all hogs, while cut-outs were made as outlined by Cole (1951) with the modification described by Pearson *et al.* (1956a).

In the first experiment, tracings were made of the outer lumbar muscle (*Gluteus medius*) and the area was measured with a compensating polar planimeter. In addition, the depth of the inner lumbar muscle (*Multifidus dorsi*) was made from the dorsal edge of the spinal canal at the lumbar-sacral junction to the central surface of the exposed *Gluteus medius*. The combined depth of both muscles was determined by measuring from the

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Figure 1. Swine carcass showing inset area for measuring lumbar lean. AB= depth of Multifidus dorsi muscle. BC=depth of Gluteus medius muscle. CD= depth of lumbar fat. AC=total depth of lumbar lean. AD=depth of lumbar lean+fat.

same location in the spinal canal to the outer edge of the *Gluteus medius*. The depth of the outer muscle was obtained by difference. All depth measurements were taken with the ruler held about parallel to the floor. The measurements in the first part of this study consisted of the combined depth of both muscles, the depth of the inner muscle, the depth of the outer muscle and the area of the outer muscle. Figure 1 illustrates the reference points for making all lumbar measurements.

Correlation coefficients were calculated for each of the lumbar lean measurements with lean cuts and primal cuts (carcass basis) as well as with loin eye area at the 10th rib. In addition, carcass length and backfat thickness were correlated with lean cuts, primal cuts and area of loin eye. Multilinear correlation coefficients were calculated for backfat thickness and carcass length combined with various lumbar lean measurements, in order to ascertain if any combination of the variables could be used more accurately to predict cut-outs and loin eye area. In order to determine the accuracy of the various lumbar lean measurements, repeatability of each lumbar lean measure was determined for 37 hog carcasses.

In the second experiment, measurements of individual lumbar muscles were not taken, but were combined into a single measurement referred to as total depth of lumbar lean, which included the total depth of both the *Gluteus medius* and the *Multifidus dorsi* muscles. In addition, a ratio was calculated by dividing the depth of the lumbar lean plus the fat at the same location by the depth of lumbar lean. Correlation coefficients were calculated for the depth of lumbar lean, and the lumbar lean-fat ratio with lean and primal cut-outs and with the loin eye area at the 10th rib. In order to ascertain whether the various lumbar lean measures were equally reliable with different weight carcasses, the carcasses were divided into three groups (120–139 lb., 140–159 lb. and 160–179 lb.) and correlation coefficients were calculated for each weight group. In addition, all groups were combined to give an over-all correlation.

In both experiments. lumbar lean measurements were made on the right side of the carcass, except for a few cases where splitting was such that the left side appeared to be more accurate and was substituted. In obtaining data for repeatability estimates, the lumbar lean measurements were first taken from the available group of carcasses along with routine measurements such as backfat thickness and length, while the second measurements for lumbar lean were obtained by remeasuring the same side.

Results and Discussion

Experiment I. Means and standard deviations of all traits under study are presented in table 1. In addition, the repeatability of each lumbar lean measurement is included in table 1. It is obvious from examination of the data that the repeatability of all lumbar lean measurements was very good, the same measurements being from 89 to 98% repeatable.

TABLE 1. MEANS, STANDARD DEVIATIONS AND REPEATABILITY OF SOME CARCASS MEASUREMENTS [a]

Items	Means and standard deviations		Repeatability estimates [b]
Depth of outer lumbar muscle (*Gluteus medius*), mm.	14.9	4.2	89
Depth of inner lumbar muscle (*Multifidus dorsi*), mm.	54.0	4.8	95
Combined depth inner and outer lumbar muscles, mm.	69.0	4.8	94
Area of outer lumbar muscle, sq. in.	1.21	0.46	98
Backfat thickness, in.	1.67	0.23	..
Carcass length, in.	29.3	1.1	..
Lean cuts-carcass basis, %	51.5	3.6	..
Primal cuts-carcass basis, %	65.7	3.0	..
Loin eye area-10th rib, sq. in.	3.65	0.58	..

[a] 142 hogs were used in calculating all means and standard deviations except the area of the outer lumbar muscle for which 177 carcasses were used.
[b] Repeatability measurements were made for 37 pigs.

Table 2 contains a summary of the correlation coefficients of the various lumbar lean measurements, backfat thickness and carcass length with lean cuts, primal cuts and loin eye area. In addition, the more promising multilinear correlation coefficients are given. The depth of the inner lumbar muscle and the over-all depth of both lumbar muscles much more accu-

TABLE 2. CORRELATION COEFFICIENTS FOR CERTAIN CARCASS MEASURES AS RELATED TO LEAN CUTS, PRIMAL CUTS AND LOIN EYE AREA

Item	Percentage lean cuts [a]	Percentage primal cuts [a]	Area of loin eye [b]
Area outer lumbar muscle	0.18	0.19	0.21
Depth outer lumbar muscle	—.02	—.14	0.02
Depth inner lumbar muscle	0.44	0.43	0.53
Combined depth both lumbar muscles	0.42	0.39	0.59
Backfat thickness	—.80	—.79	—.50
Carcass length	0.57	0.57	0.38
Multilinear correlation coefficients			
Depth inner lumbar muscle and backfat [c]	0.82	0.81	0.63
Depth inner lumbar muscle and length [d]	0.65	0.63	0.59
Combined depth lumbar muscles + backfat [c]	0.83	0.80	0.68
Combined depth lumbar muscles + length [d]	0.63	0.61	0.63
Backfat + length	0.83	0.81	0.52
Depth inner lumbar muscle + backfat [c] + length [d]	0.84	0.83	0.64
Combined depth lumbar muscles + backfat [c] + length [d]	0.84	0.82	0.68

[a] Carcass basis.
[b] Area *Longissimus dorsi* muscle at 10th rib.
[c] Average backfat thickness.
[d] Carcass length.

rately predicted lean cuts, primal cuts and loin eye area than either area or depth of the outer lumbar muscle. Thus, the individual measures of the outer lumbar muscle appeared to be of little value when taken alone, but when the outer muscle depth was included in the over-all depth of both muscles the predictive value for the area of the loin eye was slightly improved.

Backfat thickness and carcass length were both superior to any of the lumbar muscle measurements for predicting either lean or primal cuts, backfat thickness being more accurate (table 2) than length. However, the depth of the inner lumbar muscle (r=0.53) and the combined depth of both lumbar muscles (r=0.59) was somewhat more closely related to loin eye area than were either backfat thickness (r=—.50) or carcass

TABLE 3. MEANS AND STANDARD DEVIATIONS BY WEIGHT GROUPS

Item	All carcasses		120–139 lb. carcasses		140–159 lb. carcasses		160–179 lb. carcasses	
	M.	S.D.	M.	S.D.	M.	S.D.	M.	S.D.
Number in group	150		23		107		20	
Carcass weight, lb.	150.7	10.96	.....	....	.....	....	.....	....
Depth lumbar lean, mm.	68.4	5.77	65.6	5.16	68.5	5.70	71.2	5.65
Ratio depth lumbar lean and fat/depth of lumbar lean	1.54	0.10	1.52	0.09	1.54	0.11	1.58	0.10
Lean cuts—carcass, %	52.7	2.64	53.8	2.82	52.7	2.64	51.4	1.85
Primal cuts—carcass, %	65.6	2.12	66.6	2.27	65.6	2.01	64.4	2.01
Area loin eye, sq. in.	3.77	0.55	3.57	0.59	3.78	0.54	3.96	0.51
Backfat thickness, in.	1.66	0.20	1.54	0.19	1.66	0.18	1.82	0.20
Carcass length, in.	29.8	1.0	29.1	1.3	29.9	0.9	30.5	0.8

length (r=0.38). The relationship between the loin eye area and percentage lean cuts reported by Kline and Hazel (1955) is somewhat higher (r=0.66) than the values reported for lumbar lean measures with loin eye area in this study; but, percentage lean cuts cannot be obtained on the intact carcass. Furthermore, the association between lean cuts and loin eye area reported by the same investigators are higher than those reported by other workers, who have reported correlations of 0.52 (Pearson *et al.*, 1956b) and 0.50 (Price *et al.*, 1957).

Results of this study show that either the depth of the inner lumbar muscle (*Multifidus dorsi*) or the over-all depth of both the inner lumbar muscle and the outer lumbar muscle (*Gluteus medius*) can be used as an indication of area of the loin eye. However, the area of the outer muscle was of little value in predicting loin eye area.

Experiment 2. Examination of the means by weight groups (table 3) reveals that both depth of lumbar lean and the ratio of lumbar lean plus fat to lumbar lean increased with carcass weight. An increase in size of loin eye was also apparent as weight increased. The percentage of both lean and primal cuts declined as carcass weight increased.

The correlation coefficients for the lumbar lean measures are reported in table 4. Examination of the data showed that a positive relationship

existed between total depth of the lumbar lean with both lean and primal cut-outs and with area of loin eye. Although the depth of lumbar lean could be used to predict cut-outs, the predicative value for cut-outs was lower than that found for backfat thickness in Experiment 1. However, total depth of lumbar lean again appeared to be a fairly good indicator of loin eye area except for the heavy-weight carcasses, where the value was considerably lower.

The ratio of lumbar lean plus fat to lumbar lean was negatively associated with cut-outs and area of loin eye. Use of the ratio, which included the depth of lumbar fat, resulted in considerably higher correlation coefficients with cut-outs. The relationships with lean cuts (—.74) and primal

TABLE 4. CORRELATION COEFFICIENTS FOR CERTAIN CARCASS MEASUREMENTS BY WEIGHT GROUPS WITH MEASUREMENTS OF LUMBAR LEAN

Item	All carcasses	120–139 lb. carcasses	140–159 lb. carcasses	160–179 lb. carcasses
Total depth lumbar lean×lean cuts	0.44	0.57	0.57	0.26
Total depth lumbar lean×primal cuts	0.43	0.53	0.60	0.29
Total depth lumbar×area loin eye	0.52	0.57	0.52	0.31
Ratio lumbar lean+fat/lumbar lean ×lean cuts	—.74	—.68	—.76	—.59
Ratio lumbar lean+fat/lumbar lean ×primal cuts	—.73	—.64	—.78	—.57
Ratio lumbar lean+fat/lumbar lean ×loin eye	—.50	—.60	—.57	—.37
Backfat thickness×area loin eye	—.41	—.62	—.56	—.22

cuts (—.73) are comparable to the relationship of backfat thickness to cut-outs which have been reported previously (North Central Livestock Marketing Committee, 1952; Henning and Evans, 1953; Brown *et al.*, 1951; Whiteman *et al.*, 1953; Pearson *et al.*, 1956a; Price *et al.*, 1957). Furthermore, the relationship of loin eye to the ratio of lumbar lean plus fat to depth of lumbar lean are about equal to the correlation between loin eye area and percentage lean cuts reported in the literature (Kline and Hazel, 1955; Pearson *et al.*, 1956b; Price *et al.*, 1957). Thus, use of the ratio of lumbar lean plus fat to depth of lumbar lean appears to be a useful tool in evaluating intact pork carcasses for cut-outs and loin eye area.

It is worthy of note that the heavy carcasses (160–179 lb.) showed lower relationships for lumbar lean measures with both cut-outs and loin eye area than either the light (120–139 lb.) or medium weight carcasses (140–159 lb.). Similarly, there was less association between backfat thickness and loin eye area for the heavier carcasses than for the other two weight groups. Interestingly enough, for the heavy carcasses the association between loin eye area and the lumbar lean-fat ratio was higher than with backfat thickness. However, both relationships were so low that they were

of little predictive value. Thus, lumbar lean was a more effective indicator of carcass value for carcasses weighing from 120 to 159 lb. than for those weighing 160 lb. and over.

Summary

Results of this study involving 292 swine carcasses indicate that depth of lumbar lean can be used as an indicator of loin eye area. However, the ratio of depth of lumbar lean plus fat to depth of lumbar lean was equally as reliable an indicator of loin eye area and had the added advantage of being a good indicator of carcass cut-outs. Although the various lumbar lean measurements can be used in carcass grading, their use appeared to have little advantage over the use of backfat alone.

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FACTORS AFFECTING CONDITION AND CONFORMATION OF CROSSBRED SPRING LAMBS [1]

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THE market condition or grade of a lamb constitutes the major basis on which relative sale price per pound is determined. Fatness is widely accepted as an index of nutritive value and taste appeal of the carcass and is assumed to stimulate consumer acceptance. Conformation is expressed as a relative symmetry of live body form and is assumed indicative of the proportion of primal cuts which would be realized from the resulting carcass. In spring lamb production the objective is a lamb of such size, form and fatness to command top price on the existing market. In general, assumed hereditary breed differences in attaining maturity with respect to skeletal, muscular and fat development determine the comparative suitability of particular breeds for production of spring lambs.

The purpose of this study was to evaluate the effect of various hereditary and environmental potential sources of variation on condition and conformation of spring lambs.

Materials and Methods

The data in this study were from the files of the Oregon State College Sheep Improvement Program. The matings, management procedures and numbers of lambs in the various classifications were as described by de Baca *et al.* (1956) and Bogart *et al.* (1957). The animals in this study are genetically unique in that segregation in the dam breed groups should be occurring at a maximum. Each lamb on which the measurements were taken for this study was, in fact, the result of four breed combinations. The dams of the lambs were the misnomered First-cross ewes and Second-cross ewes described by de Baca *et al.* (1956). The First-cross ewes were derived by crossing purebred Hampshire, Border Leicester, Cheviot, and Romney sires onto Lincoln x Rambouillet-cross ewes occasioning thus a three breed cross. The Second-cross ewes resulted from backcrossing the First-cross ewes to sires of their respective sire breed. The sires of the lambs from the First- and Second-cross ewes were either Suffolk or Southdown. Production from First-cross and Second-cross ewes could not be compared in absolute terms as a wide age difference existed between the two crosses. Age of ewe differences within crosses and within years probably contribute a small amount of variation to the unmeasured portion. Otherwise the unmeasured portion of variation is by nature of the breeding design due to genetic and genetic-environmental interaction differences.

[1] Technical Paper 1212. Oregon Agricultural Experiment Station.
[2] Department of Dairy and Animal Husbandry.

The segregation potential made possible by the genetic diversity of the breeds crossed in the development of the ewe groups would lead to the expectation that large individual genetic differences would become apparent among the offspring of these First- and Second-cross ewes.

The condition evaluation was the average of the scores assigned each lamb at weaning by a committee of three scorers. A lamb with a score between 90 and 100 corresponded to a Prime grade; between 80 and 89, Choice; 70 and 79, Good; 60 and 69, Utility; and below 60, Cull. Comparable scores for conformation corresponded respectively to Excellent, Good, Average, Below Average, and Poor body form. In evaluating conformation, relative symmetry of body form was emphasized rather than size, since overweight should not be a factor at this age of slaughter and a balanced carcass is desired irrespective of size.

The data were handled by least squares analysis (Anderson and Bancroft, 1952). The basic model described by de Baca *et al.* (1956) p. 671) was utilized in the estimation of effects. The inferential explanation of the components of the model is also discussed by de Baca *et al.* 1956.

Each observation on condition and conformation was assumed to be the sum of the influences considered in the following basic model:

$$Y_{ijkm}=M+R_i+E_j+(RE)_{ij}+B_k+S_m+(BS)_{km}+e_{ijkm}$$

where Y_{ijkm}=condition score or conformation score of the lamb

M =an effect common to all lambs

R_i =a constant for the i^{th} ram breed

E_j =a constant for the j^{th} ewe breed

$(RE)_{ij}$=a constant for the i^{th} ram breed with the j^{th} ewe breed, the interaction effect between the i^{th} ram breed and the j^{th} ewe breed

B_k =a constant for the k^{th} birth type, single or twin

S_m =a constant for the m^{th} sex, wether or ewe

$(BS)_{km}$=a constant for the k^{th} birth type with the m^{th} sex, the interaction effect between the k^{th} birth type and the m^{th} sex

e_{ijkm} =error or failure of the model accurately to measure the individual trait of the lamb

In the analysis of condition scores, a second model which incorporated the effect of birth weight was used. In view of the general association between small ultimate size and early fattening tendency, and the association between birth weight and subsequent weight, the effect of birth weight on condition was measured to ascertain whether fattening tendency is related to birth weight. This second model was similar to the basic model with the addition of b_wW, where b_w refers to the regression coefficient of condition score on birth weight and W refers to the birth weight. No further mention will be made of this presumed covariable since the regression of condition score on birth weight was essentially zero, and the change due to removal of this probable source of variation was apparent neither in the constants nor in the error variance. The analyses on con-

formation scores were conducted for lambs born in both of the years 1952 and 1953 only on lambs from Second-cross ewes.

The conformation data were handled by means of the basic model and also by incorporation into the basic model of an equation to estimate the effect of condition on the conformation score. The latter was accomplished by the addition of b_eC to the basic model, where b_e refers to the regression of conformation score on condition score and C refers to the condition score. The estimated constants represent deviations from the mean effect, while the regression coefficient b_n represents the average change in the dependent variable per unit change in the n^{th} independent variable.

Results and Discussion

The results will be presented separately for condition and conformation scores and the significance of the results will be discussed along with the data.

Condition. Estimates of the effects which various factors exert on the condition score of a lamb are presented in table 1, and the four analyses of variance of the various effects are presented in table 2. Coefficients of determination of 0.38 to 0.65 give emphasis, in the determination of the condition of a lamb, to the importance of (1) individual variation in the lambs resulting from segregation in the crossbred ewes and (2) maternal effects due to genetic differences in the crossbred ewes which were themselves produced from segregating genotypes. By virtue of the design, both of these sources contribute to the residual variation which is expected to be largely genetic variation.

The analyses of variance (table 2) indicate that the effect of birth type was of greater relative importance than breed combination in regard to its effect on condition score at weaning. Moreover, birth type was the only consistently significant source of variation. The differences in condition score between twins and singles ranged from 5.22 to 10.26 units. With single and twin lambs of similar genotype, the extra milk available to those raised singly should permit greater synthesis of flesh, either fat or protein. This difference was reflected in condition scores at weaning. Creep-feeding of twins should minimize this effect and benefit should be realized in both grade and weight.

The analyses of variance (table 2) comparing breeds of sire, ewe-breed groups and sire-breed x ewe-breed interaction indicate significance among breeds or breed crosses in only one of the four analyses. The differences between Suffolk-sired and Southdown-sired lambs were not consistent, and again significance occurred also in only one analysis of the four. It may be inferred that differences which can be detected by condition score do not exist to differentiate between the fatness of Southdown-sired and Suffolk-sired lambs at these weights and ages. Either differences in fattening tendency between Suffolk and Southdown-sired lambs do not exist or the

scores are not adequate to distinguish them. It is, however, important to notice in table 1 that differences do exist in condition score effects of specific ewe-breeds and various specific ewe-breed x sire-breed interactions and that these differences are rather consistent in direction. Although

TABLE 1. ESTIMATES OF THE EFFECTS OF CERTAIN VARIABLES ON CONDITION SCORES OF LAMBS BORN IN 1952 AND 1953 FROM FIRST- AND SECOND-CROSS EWES BY SUFFOLK AND SOUTHDOWN SIRES

Variable	Symbol	Value			
		1952		1953	
		First cross	Second cross	First cross	Second cross
Variance accounted for by regression	R^2	0.65	0.55	0.38	0.43
Error variance	s^2	17.6	18.1	35.5	31.0
Sample size	n	66	57	87	70
Mean	M	84.34	82.85	87.23	86.29
Suffolk ram	R_1	0.85	—2.62	—4.84*	0.11
Southdown ram	R_2	—.85	2.62	4.84*	—.11
Hampshire-cross ewe	E_1	5.40*	0.68	1.26	3.48*
B. Leicester-cross ewe	E_2	0.16	0.58	—4.18*	0.23
Chevoit-cross ewe	E_3	2.20	2.26	2.07	—1.22
Romney-cross ewe	E_4	—7.77*	—3.52	0.85	—2.50
Suff. and Hamp.-cross	$(RE)_{11}$	—1.47	1.34	0.07	—1.86
Suff. and B.L.-cross	$(RE)_{12}$	—1.44	—1.19	2.02	—1.55
Suff. and Chev.-cross	$(RE)_{13}$	—.04	0.16	—.22	1.04
Suff. and Rom.-cross	$(RE)_{14}$	2.95*	—.31	—1.88	2.37
S'down and Hamp.-cross	$(RE)_{21}$	1.47	—1.34	—.07	1.86
S'down and B.L.-cross	$(RE)_{22}$	1.44	1.19	—2.02	1.55
S'down and Chev.-cross	$(RE)_{23}$	0.04	—.16	0.22	—1.04
S'down and Rom.-cross	$(RE)_{24}$	—2.95*	0.31	1.88	—2.37
Single	B_1	5.13*	2.61*	2.61*	3.55*
Twin	B_2	—5.13*	—2.61*	—2.61*	—3.55*
Wether	S_1	—.27	—.68	—.39	—.74
Ewe	S_2	0.26	0.68	0.39	0.73
Single and wether	$(BS)_{11}$	0.53	0.51	—.27	—.07
Single and ewe	$(BS)_{12}$	—.53	—.51	0.27	0.06
Twin and wether	$(BS)_{21}$	—.53	—.51	0.27	0.07
Twin and ewe	$(BS)_{22}$	0.53	0.51	—.27	—.06

* Significantly different from zero at $P<.05$.

several of the estimated constants are not significantly different from zero, there are those which are different from each other; yet the test of such differences is not valid because the intended significance level will be greater than the actual (Li, 1957).

These data show, therefore, as do those of Hazel and Terrill (1946) and Neville *et al.* (1958) that differences in condition among breeds do

exist at weaning. The ranking of the breeds compares directly with the findings of Nelson *et al.* (1950), and Horlacher *et al.* (1922). Lambs from Hampshire-cross and Cheviot-cross ewes consistently tended to be scored higher than those from Border Leicester-cross ewes and those from Romney-cross ewes with the latter being scored the lowest. From these observations together with the lack of sire-breed differnces, it becomes apparent that (1) post-natal maternal effects associated with breed of dam exert more influence than does the inheritance from the immediate sire breed, or (2) that the inheritance from Hampshire and Cheviot grandsires is more influential on the ability of the lamb to fatten than is inheritance from the

TABLE 2. FOUR ANALYSES OF VARIANCE OF CERTAIN EFFECTS ON CONDITION SCORES IN LAMBS

Source of variation	Degrees of freedom	Mean square			
		First-cross		Second-cross	
		1952	1953	1952	1953
Sire breed	1	13.82	281.85**	44.33	0.16
Dam breed	3	106.12**	89.42	14.81	47.72
Sire x Dam breed	3	70.01*	40.33	11.81	67.36
Birth type	1	611.25**	235.03**	167.29**	382.95**
Sex	1	1.98	6.88	8.52	12.67
Birth type x Sex	1	12.86	3.73	11.06	0.25
Error		17.60	35.50	18.10	31.00
Error d/f		46	59	55	76

* Significantly different from zero at $P<.05$.
** Significantly different from zero at $P<.01$.

Suffolk or Southdown sires. The former explanation would seem the logical one.

Examination of the estimates for ewe-breed x ram-breed combination in specific cases (table 1) indicate that breed-cross interaction effects or genetic-environmental interactions are operative on the condition of the crossbred lambs. Except in one case, the Border Leicester-cross ewes produced higher scoring lambs from Southdown sires than from Suffolk sires. On the other hand, lambs from Hampshire-cross, Cheviot-cross and Romney-cross ewes gave relatively similar results whether lambs were sired by Suffolk or Southdown rams.

The similarity in the ultimate large size of the Suffolk and Border Leicester breeds as opposed to the smallness of the Southdown, in conjunction with interpretation of the condition scores, would lead one to suppose that at the age these measurements were taken the Border Leicester-cross x Suffolk lambs were to a greater extent in the skeletal and/or muscular stages of growth than the Border Leicester-cross x Southdown lambs which had already passed through this stage of growth and were in the fattening phase. This is explainable as an interaction of meta-

bolic type with post-natal maternal effects in which lambs with an inherently slower growth rate were being afforded a higher plane of post-natal nutrition relative to body weight than were the inherently faster growing Border Leicester-cross x Suffolk crosses.

There was a consistent though non-significant tendency for ewe lambs to score higher than wethers. The effects of interaction of birth type and sex were inconsistent and unimportant.

TABLE 3. ESTIMATES OF THE EFFECTS OF CERTAIN VARIABLES ON CONFORMATION SCORES OF LAMBS BORN IN 1952 AND 1953 FROM SECOND-CROSS EWES ONLY AND BY SUFFOLK AND SOUTHDOWN SIRES

		Value			
		1952		1953	
Variable	Symbol	Condition ignored	Condition adjusted	Condition ignored	Condition adjusted
Variance accounted for by regression	R^2	0.25	0.34	0.42	0.89
Error variance	s^2	26.5	23.6	64.6	12.1
Sample size	n	57	57	70	70
Mean	M	83.89	31.71[a]	83.93	—25.41[a]
Suffolk ram	R_1	—2.87	—1.25	—3.01	—3.15*
Southdown ram	R_2	2.87	1.25	3.01	3.15*
Hampshire-cross ewe	E_1	1.34	0.80	3.15	—1.47
B. Leicester-cross ewe	E_2	—.17	—.66	—2.78	—2.35
Chevoit-cross ewe	E_3	1.33	0.28	2.28	1.11
Romney-cross ewe	E_4	—2.50	—.43	—2.66	0.54
Suff. and Hamp.-cross	$(RE)_{11}$	0.64	—.20	—1.49	0.89
Suff. and B.L.-cross	$(RE)_{12}$	—1.36	—.62	—1.60	0.38
Suff. and Chev.-cross	$(RE)_{13}$	0.84	0.74	1.44	0.38
Suff. and Rom.-cross	$(RE)_{14}$	—.12	0.08	1.65	—1.38
S'down and Hamp.-cross	$(RE)_{21}$	—.64	0.20	1.49	—.89
S'down and B.L.-cross	$(RE)_{22}$	1.36	0.62	1.60	—.38
S'down and Chev.-cross	$(RE)_{23}$	—.84	—.74	—1.44	—.11
S'down and Rom.-cross	$(RE)_{24}$	0.12	—.08	—1.65	1.38
Single	B_1	2.36*	0.74	1.90	—2.64*
Twin	B_2	—2.36*	—.74	—1.90	2.64*
Wether	S_1	—1.30	—.61	1.22	2.16
Ewe	S_2	1.30	0.61	—1.22	—2.16
Single and wether	$(BS)_{11}$	0.39	0.07	—.51	—.43
Single and ewe	$(BS)_{12}$	—.39	—.07	0.51	0.43
Twin and wether	$(BS)_{21}$	—.39	—.07	0.51	0.43
Twin and ewe	$(BS)_{22}$	0.39	0.07	—.51	—.43
Condition score	b_C		0.62**		1.27**

[a] Estimated mean at condition score equal to zero.
* Significantly different from zero at $P<.05$.
** Significantly different from zero at $P<.01$.

Conformation. Estimates of the effects of the variables incorporated in the statistical models are presented in table 3 for conformation scores of lambs born from the Second-cross ewes in the years 1952 and 1953, both ignoring and adjusting the probable effect of condition.

Among the effects due to breeds *per se* and among the effects due to specific breed crosses, statistical significance with quantitative and biological meaning was lacking. Consistent tendencies existed, however, for Southdown-sired lambs to score higher in conformation than those from Suffolk rams, and for lambs for Hampshire-cross and Cheviot-cross ewes to be scored higher than those from Border Leicester-cross and Romney-cross ewes.

Tendencies were also noted for lambs from Hampshire-cross, Cheviot-cross and Romney-cross ewes to be of similar conformation whether sired by Southdown or Suffolk rams. When the effect of condition score on conformation score was ignored, lambs from Border Leicester-cross ewes if sired by Southdown rams, scored somewhat higher than if sired by Suffolk rams. These tendencies were removed, however, by adjusting for the effect of condition.

Birth type imparted an important effect on conformation score. With condition ignored, the difference between single and twin lambs amounted to 3.8 and 4.7 units. Adjustment for condition score minimized the birth type effect in the 1952 analysis and overcompensated for it in the 1953 analysis.

Sex and the interaction of sex and birth type displayed no meaningful effect on conformation score.

The regression coefficients of conformation score on condition score were 0.62 and 1.27 in 1952 and 1953, respectively. That is, for each point increase in condition score a lamb was scored on the average 0.62 points higher in conformation in 1952 and 1.27 points higher in 1953. This indicates that animals that appear to have a highly symmetrical body form are also those scored high in condition and infers that symmetry of body form is highly dependent on degree of fatness and total fleshiness. These results are consistent with the conclusions of Hazel and Terrill (1946, p. 322) relative to this association between condition score and body type. The lesser relationship between condition and conformation in 1952 would indicate greater objectivity in scoring in 1952.

It is evident from the magnitude of the coefficients of determination (0.25 to 0.89) that conformation score of lambs in the manner thus determined is highly subjective and highly dependent on the condition of the lamb at scoring. The estimates, although the data have a subjective basis, indicate greater hereditary implication for condition score than for conformation scores. This is to be expected in view of the lower heritability estimates for body type than for condition reported by Hazel and Terrill (1946).

Summary

The differences in condition score between Suffolk-sired and Southdown-sired lambs were not consistent. Similarly, differences in conformation scores were not significant; however, the tendency was for Southdown-sired lambs to be scored higher. Consistent tendencies were for Hampshire-cross and Cheviot-cross lambs to score higher in condition than Border Leicester-cross and Romney-cross lambs, the latter scoring the lowest. Conformation scores displayed similar tendencies among ewe-breeds.

The importance of specific sire-breed x ewe breed cross in producing lambs with high condition is apparent, in that Border Leicester-cross ewes produced higher scoring lambs from Southdown sires than from Suffolk sires. Lambs from Hampshire-cross, Cheviot-cross and Romney-cross ewes performed equally well when their lambs were sired by either Southdown or Suffolk rams. The interaction of inherent growth rates from the sire breed with post-natal maternal effect of ewe breed would account for the breed interaction in fattening response of lambs.

The residual variation is largely genetically influenced variation by nature of the breeding design. It is partly a response to genetically different pre- and post-natal maternal environments, and partly due to widely segregating genetic differences in the growth pattern among the lambs, and assumed an important role in the determination of condition in lambs.

Birth type contributed the greatest comparative effect on condition score of any of the factors studied. Twin lambs scored from 5.22 to 10.26 points lower than single lambs. Conformation scores were significantly different between single and twin lambs.

No differences attributable to sex or to the interaction of birth type and sex existed in condition or conformation scores. There was no association between birth weights of lambs and their condition score at weaning.

The regression of conformation score on condition score indicated that for each unit increase in condition score a lamb would be scored 0.62 to 1.27 units higher in conformation under the existing scoring system, and that the effects of all other variables on conformation scores were removed by adjusting for condition score. The conformation score assigned to a lamb is thus apparently largely dependent on the condition of the lamb at the time of scoring.

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GAINS AND GRADES OF BEEF STEERS IN THE GULF COAST REGION [1]

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THE rapid increase in population of the United States dictates a close study of the future food supply of the nation. More beef must be produced and it must be produced more efficiently. Improved management practices and improved nutrition will certainly play a great role in the continuous effort towards efficiency, and in addition the application of animal genetics in the development of superior cattle is vital. Although cattle have been fattened traditionally in the North-Central (corn belt) area, a great deal of interest is being shown at the present time in feeding cattle for market in the South. The cattle population in this region is made up of many different types. A large number of Hereford and Angus cattle and a smaller number of Shorthorn cattle are found here. In addition, a great many cattle, particularly in Texas, Louisiana, and Florida are Brahman crossbreds, a more recent development being the use of Charolaise cattle in commercial beef cattle herds.

Since fattening has not been a very large part of the beef cattle operation in the South, very few data are available for evaluation of the feedlot performance of the many different types of animals produced here. In view of the number of cattle containing some Brahman breeding in the Southern region it is of particular importance to compare the feedlot performance of these cattle with that of the English breeds. The increasing utilization of Charolaise cattle throughout the country makes the performance of this breed also of considerable interest. The investigation reported in this paper is a part of a large scale crossbreeding experiment conducted at this station over a five-year period designed to yield information on many traits of performance of purebred and crossbred cattle in the Gulf Coast Region. This paper will deal primarily with rates of gain and grades of 24 different types of cattle fed out on a wheat and rye grass pasture for a period of 168 days in each of the five years.

Experimental

The steers used in this experiment were produced in a crossbreeding experiment started at this station in 1952. Six herds each of 32 cows were

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assembled at that time. Each herd was made up of eight cows from the Angus, Hereford, Brahman, and Brangus breeds. The Brangus cows were loaned to this station by the Iberia Livestock Experiment Farm in Jeanerette, Louisiana. These cattle are called Brahman-Angus but are referred to as Brangus in this paper in order to distinguish them from the Brahman and Angus crosses made in this study. This line of cattle was treated as a pure breed of cattle. The Brahman cattle were all purebred while the Angus and Hereford cattle were both grade and purebred. Each of the six herds was bred to a bull of a different breed. The six breeds represented were Angus, Brahman, Brangus, Charolaise, Hereford and Shorthorn. Some replacements were made in all breeds of cows throughout the course of this experiment when this became necessary through losses due to death, disease, or reproductive failure. A new bull was selected each year to represent each of these breeds and the herds were rotated to a bull of a different breed each year. In this way, the crosses and purebreds were produced by different bulls and different cows each year. The females produced in this work have been retained and are being utilized in further breeding studies.

The cattle were pasture mated during a breeding season from April 1 to July 1. The birth date, birth weight, color, and sex of each calf were recorded within 24 hours after birth. The calves were castrated and dehorned early in April and at that time weights were recorded on all calves and at 28-day intervals thereafter. Toward the end of the summer the intervals were reduced to 14 days in order to insure a more accurate adjustment to a common age. The calves born in any given year were all weaned on the same day, when they averaged approximately 8 months of age. All calves were given a slaughter calf and a feeder calf grade at that time and the heifer calves were also given a type grade.

The steers were kept in a holding lot for a two-week period after weaning and started on a small amount of grain. At the end of the two weeks the steers were put onto a 50-acre pasture of wheat and rye grass where they remained for 168 days. The steers had no shelter available and were fed out of open troughs. The grain supplement was a mixture of 6 parts cracked shelled corn and 1 part cottonseed meal (41% protein). The average consumption for the five-year period was limited to 7.5 lb. per day. Grass hay was supplied free choice and the animals had access to salt and a standard mineral mixture. The weights of the steers were recorded at 28-day intervals throughout the 168-day feeding period. Although it was not expected that steers fed out on a grass pasture with a grain supplement under the conditions described here would gain as rapidly as in a drylot, it was assumed that the different types of cattle would respond in a fashion comparable to that of drylot feeding. At the close of the feeding period the steers were given a slaughter grade and then moved to the University's Meats Laboratory where they were slaughtered. Detailed slaughter and cooking data and carcass measurements were then collected.

The data were analyzed by the method of fitting constants as described by Kempthorne (1952) for a 2-way classification with unequal numbers and no interaction. This method of analysis adjusts for unequal frequencies under the assumption of no interaction between years and breeding groups. The model was

$$y_{ijk}=\mu+a_i+b_j+e_{ijk}$$

where y_{ijk}=the observation of the kth steer for the jth breed group in the ith year

$i=1,\ldots, 5$

$j=1,\ldots, 24$

μ=an effect common to all steers

a_i=an effect common to all steers born in the ith year

b_j=an effect common to all steers born in the jth breed group

e_{ijk}=an effect peculiar to each individual steer

TABLE 1. ANNUAL RESULTS FOR RATE OF GAIN, SLAUGHTER GRADE, AND WEIGHT PER DAY OF AGE

Year	No. of steers	Rate of gain		Slaughter grade[a]		Weight per day of age	
		Estimated mean, lb.[b]	Standard error, lb.[c]	Estimated mean	Standard error	Estimated mean, lb.	Standard error, lb.
1953–54	54	1.69	0.035	10.02	0.203	1.76	0.025
1954–55	49	1.71	.037	11.10	.213	1.82	.026
1955–56	57	1.91	.034	11.16	.195	1.80	.024
1956–57	54	1.78	.035	11.69	.203	1.85	.025
1957–58	61	1.58	.033	9.31	.191	1.64	.023

[a] Grading system: 17–15, prime; 14–12, choice; 11–9, good; 8–6, commercial; 5–3, utility.

[b] Estimated by least squares.

[c] Error standard deviations for rate of gain, slaughter grade, and weight per day of age were: 0.25 lb., 1.44, and 0.17., respectively.

The tests of significance were made by the use of Duncan's "New Multiple Range Test" (1955, 1957), as extended by Kramer (1956, 1957) for making tests between means with unequal numbers of replications and correlated adjusted means.

Results and Discussion

Years. The number of steers fed out during the course of this experiment varied from 49 to 61 per year, with a total for the five-year period of 275 steers. Since the steers were fed on pasture with no shelter available other than scattered trees, the weather had a noticeable effect on the rates of gain. Periods of cold, rainy weather were accompanied always by depressed rates of gain. The amount of rainfall also influenced the successful development of pasture, and the heavy rains during the fall and winter of the 1957–58 season hampered the pasture establishment and growth very seriously. A particularly favorable season in 1955–56 helped cause unusually good gains for the group of steers fed that year. An early planting of the wheat and rye grass was possible in the fall of 1955 and moderate rain at favorable intervals promoted excellent pasture growth. The yearly

fluctuations can be seen in table 1 which presents the annual results for rate of gain. The same table presents the slaughter grades which were placed on these steers by a committee from the University. The slaughter grades are live-animal grades, made at the time the steers were last weighed. The slaughter grades follow the annual rates of gain quite closely, with the exception of the 1956–57 grades which were a little higher than would be expected from the rate of gain for that year. A third trait, weight per day of age, was included in this table since many of the types of cattle produced in this experiment performed quite differently in pre- and post-weaning periods. The inherent growth potential of an animal can probably be seen determined from a consideration of these two periods together, as in a weight per day of age measurement, rather than a separate consideration of each period. The figures in table 1 indicate that the weights per day of age were quite similar for the first four years, the weights for the last year dropping off considerably. The smaller weights per day of age in this year were due both to lower weaning weights for that group of calves and also to the lower rates of gain after weaning.

Sires. The design of this experiment made it possible to group the data in several different ways in order to study points of particular interest. By grouping all of the calves sired by each of the six different breeds of bulls, it was possible to make comparisons among these breeds of bulls when they had all been mated to the same four breeds of cows. The data are presented by a sire grouping arrangement in table 2. The numbers of steers sired by each breed of bull did not vary greatly, ranging from 42 to 50. An inspection of the rates of gain showed that while the variation among the sire groups was not great, bulls of English breeding and Charolaise breeding did sire calves which gained better on feed.

These results were in agreement with the report by Black, Semple and Lush (1934) who found that, on the whole, the daily gains of 62 Hereford and 55 Shorthorn steers were moderately greater than the gains of 123 Brahman-Shorthorn and 24 Brahman-Hereford steers in a Texas study. However, they found practically no difference in the total feed consumed per 100 lb. of live weight between the non-Brahman and part Brahman steers. The results of the tests of significance are presented at the bottom of the table. A study of the slaughter grades placed on these steers again brings out the ability of the English breeds to perform well on feed. A very significant change was noted in the ranking of the Charolaise steers. Although these steers gained very well on feed, they ranked fifth in slaughter grade, the lack of finish on these animals lowering their grades considerably. The Charolaise steers also had an excellent rate of growth during the pre-weaning period but nevertheless had low slaughter calf grades at that time. The ability of the Charolaise steers to grow at a rapid rate prior to and after weaning was further emphasized by the weights per day of age attained by these animals, as shown in the third section of table 2. The steers sired by the Shorthorn, Brahman, and

TABLE 2. RATE OF GAIN, SLAUGHTER GRADE, AND WEIGHT PER DAY OF AGE RANKED BY SIRE GROUPS AND TESTS OF SIGNIFICANCE AMONG SIRE GROUPS

Rate of gain				Slaughter grade				Weight per day of age			
Breed of sire	No. of steers	Estimated mean, lb.	Standard error, lb.	Breed of sire	No. of steers	Estimated mean, lb.	Standard error, lb.	Breed of sire	No. of steers	Estimated mean, lb.	Standard error, lb.
Shorthorn	50	1.82	0.037	Hereford	47	11.41	0.215	Charolaise	44	1.86	0.027
Charolaise	44	1.79	.038	Shorthorn	50	11.38	.212	Shorthorn	50	1.80	.026
Hereford	47	1.75	.037	Angus	49	10.64	.213	Brahman	42	1.80	.027
Angus	49	1.73	.037	Brahman	42	10.52	.224	Hereford	47	1.79	.026
Brahman	42	1.67	.039	Charolaise	44	10.07	.222	Brangus	43	1.70	.027
Brangus	43	1.65	.039	Brangus	43	9.71	.223	Angus	49	1.70	.026

Results of tests of significance[a, b]: Rate of gain—(S, C, H, A), (H, A, B, BA)
Slaughter grade—(H, S), (A, B, C), (C, BA)
Weight per day of age—(C, S, B, H), (BA, A)

[a] Any two groups that do not appear together within the same parentheses differ significantly. Any two groups that appear together within the same parentheses do not differ significantly.

[b] The abbreviations used in the tests of significance are: A=Angus; B=Brahman; BA=Brangus; C=Charolaise; H=Hereford; S=Shorthorn.

Hereford bulls had almost identical weights per day of age, while the Brangus and Angus were noticeably lower in this trait.

Dams. When the steers were grouped by breed of dam, some interesting results were noted. The steers raised by Hereford cows gained significantly more on feed than did the steers raised by the other three breeds of cows. The steers raised by Angus cows also had a significantly greater rate of gain than those out of Brangus and Brahman cows. These results are shown in table 3. Since the calves raised by Brangus and Brahman cows had a considerably greater rate of gain prior to weaning than did the calves raised by Angus and Hereford cows, this was a distinct reversal. It is felt that part of this rate of gain on feed was of a compensatory nature due to the slightly lower condition of the calves raised by Angus and Hereford cows, but also due to the ability of cattle of English breeding to perform well on feed. This ability is brought out more clearly when the performance of the individual breed groups is studied. The finishing ability of the calves raised by Hereford and Angus cows was displayed by the slaughter grades which are presented in table 3. Although the differences were not great, the steers raised by cows of English breeding averaged approximately a third of a grade higher than the steers raised by the Brangus and Brahman cows. An inspection of the third section of table 3, which presents the weights per day of age, is quite revealing as it shows that at the end of the feeding period there were no significant differences among the weights per day of age attained by the steers raised by the dams of the four different breeds. While this information might be of considerable importance in assisting a commercial cattle producer to plan his breeding program in the Gulf Coast Region, it should be pointed out that this leveling out of weights per day of age was brought about by the extra nutrition afforded these cattle while on feed. Unpublished data at this station, however, have shown that the females produced in this program have not performed in the same fashion. These heifers have been raised with a minimum concentrate supplement, making most of their gains on pasture during the summer months. A study of the information gathered to date has shown that the females raised by Brahman and Brangus cows have continued to show a greater rate of gain than those females raised by Hereford and Angus cows, up to three and one-half years of age.

Breed Groups. The results of this five-year study have shown quite definitely that calves raised by Brangus and Brahman cows averaged greater rates of gain prior to weaning (Damon *et al.*, 1959) and that steers raised by Hereford and Angus cows averaged greater rates of gain on feed, when the four breeds were studied. The design of this experiment does not yield an accurate evaluation of how much of the greater rate of gain on feed by the calves raised by Hereford and Angus cows was due to the lower condition of these calves and how much was due to the breeding of the calves. However, the data presented in table 4 are

TABLE 3. RATE OF GAIN, SLAUGHTER GRADE, AND WEIGHT PER DAY OF AGE RANKED BY DAM GROUPS AND TESTS OF SIGNIFICANCE AMONG DAM GROUPS

Rate of gain				Slaughter grade				Weight per day of age			
Breed of dam	No. of steers	Estimated mean, lb.	Standard error, lb.	Breed of dam	No. of steers	Estimated mean	Standard error	Breed of dam	No. of steers	Estimated mean, lb.	Standard error, lb.
Hereford	67	1.93	0.031	Hereford	67	11.08	0.177	Brangus	71	1.81	0.021
Angus	67	1.79	.031	Angus	67	10.81	.180	Hereford	67	1.78	.021
Brangus	71	1.64	.030	Brahman	70	10.29	.175	Angus	67	1.76	.022
Brahman	70	1.58	.030	Brangus	71	10.29	.174	Brahman	70	1.75	.021

Results of tests of significance[a]: Rate of gain—(H), (A), (BA, B)
Slaughter grade—(H, A), B, BA)
Weight per day of age—(BA, H, A, B)

[a] Any two groups that do not appear together within the same parentheses differ significantly. Any two groups that appear together within the same parentheses do not differ significantly.

TABLE 4. RATE OF GAIN, SLAUGHTER GRADE, AND WEIGHT PER DAY OF AGE RANKED BY BREED GROUPS

Rate of gain				Slaughter grade				Weight per day of age			
Breed group	No. of steers	Estimated mean, lb.	Standard error, lb.	Breed of dam	No. of steers	Estimated mean	Standard error	Breed group	No. of steers	Estimated mean, lb.	Standard error, lb.
B x H	11	2.03	0.076	S x H	12	11.77	0.419	B x A	11	1.93	0.053
C x H	11	2.01	.076	B x A	11	11.56	.437	B x H	11	1.90	.053
S x H	12	1.99	.073	S x BA	14	11.50	.386	C x H	11	1.90	.053
B x A	11	1.96	.076	S x B	8	11.49	.511	H x B	13	1.89	.048
C x A	10	1.94	.079	H x A	11	11.49	.437	S x BA	14	1.89	.047
BA x H	11	1.91	.076	B x H	11	11.45	.437	C x A	10	1.87	.055
H x H	11	1.83	.076	H x H	11	11.43	.437	S x B	8	1.87	.062
H x B	13	1.81	.069	H x B	13	11.39	.401	H x BA	12	1.86	.050
S x A	16	1.80	.063	H x BA	12	11.35	.419	C x BA	15	1.86	.045
S x BA	14	1.79	.067	C x A	10	10.99	.457	BA x H	11	1.85	.053
A x H	11	1.79	.076	A x A	10	10.81	.457	C x B	8	1.81	.062
A x A	10	1.74	.079	A x H	11	10.78	.437	B x BA	10	1.79	.055
A x B	18	1.72	.059	S x A	16	10.73	.361	A x BA	10	1.78	.055
C x BA	15	1.70	.065	BA x H	11	10.68	.437	A x B	18	1.76	.041
S x B	8	1.69	.089	A x B	18	10.65	.341	S x H	12	1.74	.050
H x A	11	1.68	.076	C x H	11	10.37	.437	H x H	11	1.73	.053
A x BA	10	1.67	.079	A x BA	10	10.32	.457	S x A	16	1.70	.044
H x BA	12	1.66	.073	B x BA	10	9.83	.457	H x A	11	1.70	.053
BA x A	9	1.60	.084	BA x B	13	9.76	.401	BA x BA	10	1.69	.055
BA x BA	10	1.56	.079	C x BA	15	9.64	.376	A x A	10	1.68	.055
C x B	8	1.53	.089	BA x A	9	9.35	.483	BA x A	9	1.65	.058
BA x B	13	1.52	.069	C x B	8	9.26	.511	BA x B	13	1.63	.048
B x BA	10	1.49	.079	B x B	10	9.22	.457	A x H	11	1.57	.053
B x B	10	1.21	.079	BA x BA	10	9.06	.457	B x B	10	1.55	.055

interpreted by the authors as a clear indication that the English breeding does have a distinct advantage in the feedlot. Although the numbers are not large in these groups, the results were consistent throughout the course of the experiment. It can be noticed from the data relating to rate of gain in table 4, that the three lowest ranking groups are those showing the largest amount of Brahman breeding. It appears that once the amount of Brahman breeding in these steers exceeded 50%, it resulted in a lowering of ability to gain well on feed. While the Brahman x Hereford and Hereford x Brahman steers have done well, it can be seen that the higher ranking groups show a predominant amount of English breeding. Several feedlot trials conducted by Ittner *et al.* (1954) in California showed similar results, as they also found that Brahman-Hereford, Hereford, and Shorthorn-Hereford steers had very similar gains on both winter and summer feeding trials. Where Brahman-Hereford and Hereford steers were compared to Brahman steers in one of their trials, they found that the Brahman gained at a considerably lower rate than the other two groups. Hubert *et al.* (1955) also found that Brahman-Hereford and grade Hereford steers had similar rates of gain when both groups of steers were produced by cows from the same herd. However, when the crossbreds were purchased from another herd in a second year, the gain of the crossbreds was a great deal lower than that of the Herefords. A comparison of Brahman and British crossbred heifers in the feedlot in Georgia by McCormick and Southwell (1957) resulted in average daily gains of 1.84 lb. for 24 Angus-Hereford heifers and 1.68 lb. for 19 Brahman-Hereford heifers, which differs considerably from the performance of the steers in this study.

The performance of the Angus and Hereford breeds and their reciprocal crosses in this study indicated that a little or no advantage was to be gained from crosses between these breeds, in the traits which were analyzed. The results in this experiment were quite similar to those of Gerlaugh *et al.* (1951) who, in a study which included the comparison of the feedlot performance of purebred Hereford, purebred Angus and the reciprocal cross steers, found that the purebred Hereford and the two crossbred groups gained more rapidly on feed than the Angus steers. The results agreed also with investigations by Knapp *et al.* (1949) in which Shorthorn-Hereford steers gained more rapidly than purebred Herefords in the feedlot. They also found that Angus-Shorthorn-Hereford steers and Hereford-Angus-Shorthorn-Hereford steers gained more rapidly than the purebred Hereford steers.

As noted previously, the steers sired by Charolaise bulls gained well on feed, particularly the Charolaise-Hereford and Charolaise-Angus crosses. The rapid rate of gain of the Charolaise-Brahman calves prior to weaning indicated a greater gain potential than these steers displayed when fed out. The slaughter grades presented in table 4 follow, in general, the rates of gain of the breed groups, the cattle of English breeding ranking

high and the Brahman crossbreds lower. The Charolaise crosses had lower grades than was expected from their rates of gain, because of their lack of finish.

An inspection of the section of table 4 presenting the weights per day of age shows that the English breeds and crosses among the English breeds did not attain the size reached by the Brahman and Charolaise crossbred cattle, in spite of their excellent performance of feed. The low weight per day of age of the purebred Brahman cattle, contrasted with the high weight per day of age of the Brahman crossbreds, emphasizes the fact that this breed is going to make its greatest contribution to the beef cattle industry in a crossbreeding program. This fact has been borne out by the large numbers of Brahman crossbred cattle found in the Southern region and also by the several new lines or breeds of cattle which are in the process of development, based on crosses with Brahman cattle.

Tests of significance have been made among these breed groups but have not been presented because of the large amount of data included in table 4. Owing to the unequal numbers involved, the size of the difference necessary to declare significance varied. The size of differences that reached significance at the 5% level varied from 0.24 to 0.53 for rate of gain; from 1.42 to 1.94 for slaughter grade, and from 0.17 to 0.24 lb. for weight per day of age.

Summary and Conclusions

The Louisiana State Experiment Station established an experiment in 1952 to evaluate and compare the performance of several different breeds of beef cattle and crosses among the breeds. Females from the Angus, Hereford, Brahman, and Brangus breeds were mated to bulls from the Angus, Hereford, Brahman, Brangus, Charolaise, and Shorthorn breeds, resulting in the production of 24 different types of cattle. The experiment included feeding out the steers on a wheat and rye grass pasture with a concentrate supplement for a 168-day period, at which time they were given a slaughter grade and transported to the University's Meat Laboratory where they were slaughtered. The results of feeding 275 steers over a five-year period have shown that steers sired by Shorthorn and Charolaise bulls averaged a greater rate of gain on feed than steers sired by Brahman and Brangus bulls. Steers sired by Hereford and Angus bulls had an average rate of gain that was intermediate between these two groups. The slaughter grades of steers sired by Hereford and Shorthorn bulls were significantly greater than the grades of steers sired by the other four breeds of bulls. Steers sired by the Brangus bulls received slaughter grades which were significantly lower than the grades of all other steers except those sired by the Charolaise bulls. Steers raised by females of the Hereford and Angus breeds showed a considerably greater rate of gain on feed than those raised by Brangus and Brahman females, and also received higher slaughter grades. Ranking of the 24 different types of

steers showed that the steers of English and Charolaise breeding gained considerably better on feed than those of predominantly Brahman breeding. However, only when the Brahman breeding exceeded 50% did this appear to influence the ability to gain on feed adversely. The slaughter grades, in general, followed the same pattern as did the rates of gain, the cattle of English breeding receiving higher slaughter grades. However, the Charolaise crosses were all graded lower than would be anticipated from their rates of gain, due the lack of finish of these steers.

Since condition and weight of the calves prior to being put on feed have an influence on rate of gain, weights per day of age at the close of the feeding trials were calculated. There were no significant differences among the weights per day of age of steers sired by Charolaise, Shorthorn, Brahman, or Hereford bulls. The weights per day of age of steers sired by Brangus and Angus bulls were significantly lower than those of the steers sired by the other four breeds of bulls. There were no significant differences among the weights per day of age of the steers raised by the four different breeds of cows.

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EFFECT OF STILBESTROL AND PELLETING AT TWO CONCENTRATE TO ROUGHAGE RATIOS ON THE PERFORMANCE AND CARCASS QUALITY OF FATTENING LAMBS

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THE use of female-like hormones, complete pelleted rations, and different concentrate to roughage ratios in lamb fattening rations has stimulated investigation. Feeding stilbestrol at levels of 0.5 to 2.5 mg. per lamb per day has been shown to increase gain and feed efficiency and to have little or no effect on carcass grade (Hale *et al.*, 1955; Light *et al.*, 1956; Preston and Burroughs, 1958). Oral stilbestrol at higher levels of 3.6 mg. per day per lamb (Hale *et al.*, 1955) and implantation of stilbestrol pellets (2 mg. to 24 mg.) in fattening lambs (Jordan, 1950; Means, 1953; Andrews and Beeson, 1953; Jordan, 1953; Bell *et al.*, 1954; Wilkinson *et al.*, 1955; Jordan, 1957) have tended to show that carcass quality was lowered by stilbestrol even though gains were improved. Stilbestrol, both oral and implant, at all levels, in general, caused the dressing percentage to be lowered.

Results with lambs fed complete pelleted rations ranging from 33% roughage to as high as 70% have shown that pelleting in most cases increased performance (Esplin *et al.*, 1957; Hogue, 1958). Data obtained with lambs fed pelleted rations in which the concentrate to roughage ratio varied from 50:50 to 20:80 showed that high roughage rations permitted gains equal or superior to those made on more concentrated rations (Neale, 1958); however, dressing percentage of lambs so fed was not reported. Preston and Burroughs (1958) found that dressing percentage was increased by high energy rations. As reviewed by Esplin *et al.*, (1957) pelleting apparently had little effect upon dressing percentage of the lambs. In most cases when pelleted high roughage rations improved the performance of lambs, there was an increase in feed consumption. The purpose of the present investigation was to study the effects of stilbestrol and pelleting at two concentrate to roughage ratios, as well as their interrelationship, upon weight gain, feed efficiency and carcass quality.

Experimental

Six hundred ninety-eight Texas old-crop feeder lambs averaging 78 lb. were allotted to eight treatments. A 2^3 factorial design was used for this experiment based upon the three treatments and their interaction. The treatments consisted of two rations, either pelleted or non-pelleted and two levels of stilbestrol (0 and 0.5 mg. per lb. of feed). The rations were

low roughage (71% concentrate and 29% roughage) and high roughage (41% concentrate and 59% roughage). Table 1 shows the composition of the two rations, and their chemical analyses. Lambs receiving the low roughage rations were adjusted to full feed by gradually increasing the corn from 35% to 55% during the first two weeks of the experiment. Both rations were self-fed to lambs for a period of 53 days. The pellets were ⅜ in. in diameter and 1 in. long. All lambs were vaccinated for enterotoxemia at the beginning of the experiment. During the experiment bi-weekly records were kept of the lot liveweight and feed consumption. At the end of the feeding period, data were obtained on the amount of

TABLE 1. COMPOSITION OF EXPERIMENTAL LAMB RATIONS

Ration type	Low roughage	High roughage
Ingredients		
Ground corn, %	55	30
Chopped alfalfa hay, %	29	59
Molasses (cane), %	10	10
Soybean meal (44%), %	5	..
Salt, %	1	1
Aureomycin, mg./lb.	7.5	7.5
Proximate analysis, %		
Moisture	15.4	15.2
Crude protein	10.9	11.0
Ether extract	3.3	2.9
Crude fiber	9.3	15.2
Ash	3.8	5.3
Nitrogen-free extract	57.3	50.4

intransit shrink from farm to market (120 miles). Yield and carcass grades were obtained at slaughter.

Results and Discussion

Performance and carcass data by treatments are shown in table 2. The effect of the two rations, pelleting and stilbestrol upon performance, yield and carcass quality are shown in table 3.

Rations. There was no significant difference in average daily gain of the lambs receiving the two rations. Lambs fed the low roughage ration required 12% less feed per lb. of gain than those fed the high roughage ration; they shrank 0.86% less and yielded 1.15% more. However, more oily carcasses were observed among lambs receiving the low roughage. There were no apparent differences in grade.

Pelleting. The effect of pelleting the two rations revealed no significant improvement in rate of gain and feed efficiency and only a slight increase in feed consumption. There was a highly significant ($P<0.01$) interaction between the gains of lambs receiving the meal and pelleted forms

TABLE 2. PERFORMANCE OF LAMBS AND CARCASS DATA

Ration	Low roughage				High roughage			
Form	Meal		Pellet		Meal		Pellet	
Stilbestrol level	0	0.5	0	0.5	0	0.5	0	0.5
Number of lambs	87	87	88	86	87	87	88	88
Initial weight, lb.[a]	78.7	77.5	77.8	76.6	78.2	77.5	76.7	77.9
Final weight, lb.[b]	107.2	109.0	104.4	105.8	101.0	106.0	102.0	109.5
Daily gain, lb.	0.53	0.58	0.50	0.55	0.42	0.52	0.48	0.60
Daily feed cons., lb.	4.59	4.38	4.09	4.41	4.29	4.32	4.91	4.89
Feed/lb. gain, lb.	8.54	7.37	8.14	8.04	10.01	8.07	10.24	8.23
Shrink, farm to market, %	6.09	6.32	5.45	5.41	6.44	6.49	7.42	6.37
Yield, %	55.22	49.80	48.82	48.36	47.92	46.54	48.91	49.23
Oily carcasses, %	9.2	6.9	14.8	12.8	0	0	3.4	1.1
Yrlg. joint carcasses, %	4.6	10.3	1.1	11.6	1.1	16.1	3.4	18.2
Grade[c]	6.8	6.7	6.6	6.7	6.8	6.7	6.7	6.8

[a] Initial on test lot weights were prorated to Texas purchase weight based upon intransit shrink.
[b] Final selling weight at meat packing plant.
[c] U.S.D.A. grading basis: Choice, 8; Low choice, 7; High good, 6; etc.

of the two rations. Pelleting increased gain on the high roughage ration and decreased it on the low roughage ration. Seemingly, the increased consumption of the pelleted high roughage ration accounted to a large extent for the gain, as the feed efficiency of neither ration was significantly affected by pelleting. Thus, it appeared that for maximum gains a high roughage ration should be pelleted, although the pelleting cost may make the gain uneconomical.

There were no apparent differences in shrink, yield, or grade. However, there was a tendency for pellet-fed lambs to have more oily carcasses.

Stilbestrol. Stilbestrol fed at the rate of 0.5 mg. per lb. of feed produced

TABLE 3. EFFECT OF RATION TYPE, PELLETING, AND STILBESTROL UPON GROWTH, FEED EFFICIENCY, YIELD AND CARCASS QUALITY

Item	Low roughage	High roughage	Pellet	Meal	With DES	Without DES
No. of lambs	348	350	350	348	348	350
Daily gain, lb.	0.54	0.51	0.53	0.52	0.56*	0.48
Daily feed consumption, lb.	4.37	4.61	4.59	4.40	4.50	4.48
Feed/lb. gain, lb.	8.02	9.14	8.66	8.50	7.93	9.23
Shrink, farm to market, %	5.82	6.68	6.16	6.34	6.15	6.35
Yield, %	49.30	48.15	48.83	48.62	48.48	48.97
Oily carcasses, %	10.9	1.1	8.0	4.0	5.1	6.9
Yrlg. joint carcasses, %	7.0	9.7	8.6	8.1	14.4	2.3
Grade[a]	6.7	6.8	6.7	6.8	6.7	6.7

[a] U.S.D.A. grading basis: Choice, 8; Low choice, 7; High good, 6; etc.
* Significant at 5% probability level.

14% faster gains ($P<0.05$) and 14% improved feed efficiency. The effect upon gain was greatest with lambs receiving the high roughage ration. This interaction cannot be attributed to differences in feed consumption because adjustment of the gains for feed consumption by covariance analysis did not appreciably affect these differences. Therefore, it appeared that stilbestrol increased utilization of feed.

Stilbestrol-fed lambs shrank 0.2% less from farm to market and yielded 0.49% less than the control lambs. This lower dressing percentage agrees with the data reported previously by other workers.

Incidence of yearling break joints on the carcasses of lambs receiving stilbestrol was 14.4% as compared to 2.3% for the controls. This observation is in agreement with the work by Henneman *et al.*, (1957) who indicated that the use of female hormones resulted in an early maturity of bone structure. Oiliness, grades and other data on carcasses of the lambs fed stilbestrol were similar to those not fed stilbestrol.

Summary

In a factorially designed experiment 698 Texas old-crop feeder lambs were allotted to eight treatments consisting of two rations, low roughage

(29% alfalfa hay) and high roughage (59% alfalfa hay) either pelleted or non-pelleted, with and without stilbestrol (0.5 mg. per lb. of feed). No appreciable differences in rate of gain were observed between the two rations. Lambs receiving the low roughage ration had a 12% improvement in feed efficiency, an 0.86% lower shrink from the feedlot to market, and a 1.15% higher yield. Pelleting the low roughage ration gave no advantage in liveweight gain or feed efficiency; it increased the number of oily carcasses. Pelleting the high roughage ration increased gain and feed consumption, but not feed efficiency, over the meal form. Stilbestrol significantly ($P<0.05$) improved both gain and feed efficiency by 14%; however, it reduced dressing percentage by 0.49 and increased the number of carcasses with yearling break joints. The grades of the lambs were similar for all treatments.

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SUPPLEMENTS TO PEANUT OIL MEAL PROTEIN FOR GROWING FATTENING SWINE

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PEANUT oil meal protein alone is not a satisfactory supplement to corn for growing swine (Brooks and Thomas, 1958). An inadequacy of the amino acid lysine is the greatest limitation in quality of this protein. Mertz *et al.* (1949), Brinegar *et al.* (1950), Becker *et al.* (1954), Pfander and Trebble (1955), Hutchinson *et al.* (1957) and Germann *et al.* (1958) have estimated the lysine requirement for optimum growth of the young pig to be 0.5% to 1% when expressed as a per cent of the total ration. The percentage of lysine in peanut oil meal is 1.28–1.38 (N.R.C., 1953; Lyman *et al.*, 1956).

Inadequate methionine also appears to limit the quality of this protein. The work of Shelton *et al.* (1959), Curtin *et al.* (1952) and Becker *et al.* (1954) indicated a methionine requirement of near 0.3% in the presence of approximately an equal amount of cystine. The National Research Council (1953) and Lyman *et al.* (1956) show only 0.49% and 0.41% methionine, respectively, in peanut oil meal.

The purpose of the work reported in this paper was to determine the effect of adding lysine and methionine, either as pure amino acid or in naturally occurring supplements, to corn-peanut oil meal rations. The effects on growth, feed efficiency and certain carcass characteristics were observed.

Experimental Procedure

Weanling pigs for these trials were divided into litter mate groups; pigs extreme in weight and type, as well as unthrifty ones were removed. Individual pigs were randomly assigned, one to each of the lots from each litter group. Treatments were then randomly assigned to lots. Pigs were self-fed on concrete floored pens 7′ x 16′. A section 7′ x 7′ of each pen was covered by an open shed. Each pig was removed from test and slaughtered at the weigh period when its weight exceeded 185 lb. Weights of the pigs were recorded at two-week intervals and feed consumption was determined for each interval.

Rations were calculated from proximate analysis of each feed ingredient and later checked by an analysis of the complete ration. The desired protein levels were obtained by adjusting the amount of corn and supplement feeds in the rations.

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Pigs were slaughtered, the carcasses split and chilled 24 to 48 hours before measurements were taken. Backfat thickness was determined on the right side of the carcass at the first rib, last rib and last lumbar vertebra. Length of the carcass was taken from the anterior edge of the first rib to the anterior edge of the aitchbone. Planimeter readings on the area of the longissimus dorsi muscle were made from tracings taken at the 10th rib of the right side after cutting this muscle perpendicular to the vertebra.

TABLE 1. COMPOSITION OF RATION FED IN TRIAL 1 [a]
(50- TO 100-POUND PIGS)

Ration description	Positive control	Basal	Plus lysine	Plus lysine and methionine	Plus blood meal	Plus fish meal
Ingredients, lb.						
Ground yellow corn	75.5	75.0	76.0	76.2	78.0	77.0
Soybean oil meal	17.5	—	—	—	—	—
Peanut oil meal	—	18.0	16.5	16.0	13.0	15.0
Alfalfa meal	5.0	5.0	5.0	5.0	5.0	5.0
L-lysine HCl (95%) [a]	—	—	0.5	0.5	—	—
DL-methionine [a]	—	—	—	0.3	—	—
Blood meal [a]	—	—	—	—	3.0	—
Menhaden fish meal	—	—	—	—	—	3.0
Mineral mix [b]	1.5	1.5	1.5	1.5	1.5	1.5
Aureofac 2-A	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin mix [c]	+	+	+	+	+	+

[a] The authors are grateful to Merck & Co. for the lysine used in these tests, to the Dow Chemical Company for the methionine and to the Wilson and Co. for the blood meal.
[b] Mineral mix, 2 parts limestone, 1 part dicalcium phosphate and 1 part salt.
[c] Vitamin mix, 600 I.U. vitamin A, 90 I.U. vitamin D, 100 mg. riboflavin and 400 mg. Ca pantothenate per lb. of feed.

Analysis of variance [3] was made on the data from each trial after first removing differences due to sex and weight by multiple covariance analyses. Significance or differences among treatment means was determined by the multiple range test as described by Duncan (1955).

Trial 1. The 36 weanling pigs used in trial 1 were allotted to treatments at random from each of six litter-mate groups. The six pigs that were most uniform in weight and type within each litter were chosen as a litter-mate group. Three litters were Tamworth X (Berkshire X Virginia Black [4]) and one litter each was of the following breeding: Hampshire X (Berkshire X Virginia Black), Hampshire X Berkshire and inbred Virginia Black. The average weight per pig in these groups was 65, 55, 53, 49, 48 and 45 lb., respectively.

[3] These analyses were made by the Statstiics Laboratory of Virginia Agricultural Experiment Station under the supervision of C. Y. Kramer.
[4] Virginia Black—Inbred line of hogs originating from Yorkshire X Montana #1 and developed by the Virginia Agricultural Experiment Station.

Composition of the rations fed until pigs averaged 100 lb. is shown in table 1. The protein content of the rations was then lowered from 16% to 14%. The amino acid supplements were reduced in the same proportion as the protein level. The blood meal was a vacuum dried product referred to as soluble blood meal.

Trial II. The objectives of this trial were essentially the same as those of the first one; however, the following changes were made: The positive control (soybean oil meal) ration was not included; alfalfa meal was removed from the rations, and a lot was added to check the effect of this supplement on the basal ration. Also, the lysine level was reduced, and

TABLE 2. COMPOSITION OF RATION FED IN TRIAL 2 [a]
(40- TO 75-POUND PIGS)

Ration description	Basal	Plus alfalfa meal	Plus lysine	Plus lysine and methionine	Plus blood meal	Plus fish meal	Plus fish sol.
Ingredients, lb.							
Ground yellow corn	79.0	75.0	79.4	79.5	81.5	81.0	78.0
Peanut oil meal	19.0	18.0	18.3	18.0	14.0	12.0	17.0
Alfalfa meal	....	5.0	....	....	....	....	....
L-lysine HCl (95%)	....	....	0.3	0.3	....	....	....
DL-methionine	....	....	....	0.2	....	....	....
Blood meal	....	....	....	....	2.5	....	....
Menhaden fish meal	....	....	....	....	....	5.0	....
Fish solubles	....	....	....	....	....	....	3.0
Mineral mix [b]	2.0	2.0	2.0	2.0	2.0	2.0	2.0

[a] Each ration was fortified with 50,000 I.U. vitamin A, 9,000 I.U. viatmin D, 50 mg. riboflavin, 400 mg. calcium pantothenate and 1,500 mg. Aureomycin.

[b] Mineral mix contained 2 parts limestone, 1 part defluorinated phosphate, 1 part salt with 25 gm. zinc sulfate added to each 100 lb.

the fish meal level was increased. A ration containing fish solubles was included to determine if this material would adequately supplement peanut protein. The protein levels were lowered at lighter weights, and lighter pigs were used at the beginning of the test. The protein levels used in this trial were 16%, 14% and 12% for pigs 40–75 lb., 75–150 lb. and 150–200 lb., respectively. Amino acid supplements were maintained proportional to protein. Composition of the rations used for pigs 40–75 pounds is shown in table 2.

Pigs were grouped for allotting by the same method used in the first trial. The 49 weanling pigs were randomly allotted to treatments from each of seven litter-mate groups of seven pigs each. Four of the litters were Duroc X (Hampshire X Virginia Black) averaging 47, 44, 39 and 36 lb. per pig and three litter-mate groups of purebred Hampshires averaging 47, 47 and 36 lb. per pig.

Results and Discussion

Average performance and carcass data are shown in table 3 for the first trial and table 4 for the second trial. Adjusted means are shown below the table in each instance where the mean differences are significant.

In both trials, pigs fed rations in which peanut oil meal or peanut oil meal and alfalfa were the only sources of protein other than corn made lower gains than pigs on the other rations. These differences were significant between all lots except the one in which a high level of lysine was used

TABLE 3. EFFECT OF TREATMENT ON RATE OF GAIN, FEED EFFICIENCY AND CARCASS CHARACTERISTICS

Trial 1

Ration description	SBOM	Basal	Plus lysine	Plus lysine and methionine	Plus blood meal	Plus fish meal
No. pigs	6	6	6	6	6	6
Initial wt., lb.	52	55	50	51	53	54
Final wt., lb.	208	193	199	203	202	209
Daily gain, lb.	1.54	1.10	1.41	1.54	1.50	1.45
Feed per lb. gain	3.54	5.28	4.01	3.57	3.65	3.75
Carcass length, in.	30.0	30.1	29.3	29.8	29.7	30.1
Backfat, in.	1.4	1.4	1.4	1.5	1.4	1.4
Loin area, in.	3.58	3.11	4.28	3.64	3.92	3.69

Analysis of variance

Source	df	Mean squares			
		Daily gain	Carcass length	Backfat	Loin eye area at 10th rib
Treatment	5	0.125**	0.845	0.050	0.984**
Outcome groups	5	0.184**	4.116**	0.678**	0.759**
Error	21	0.018	0.664	0.567	0.098

Adj. mean daily gain [a]

P.M.	P.M.+L.	P.M.+L.+M.	P.M.+F.M.	P.M.+Bl.M.	S.B.O.M.
1.19	1.31	1.48	1.51	1.53	1.53

Adj. mean loin area

P.M.	P.M.+F.M.	P.M.+L.+M.	S.B.O.M.	P.M.+Bl.M.	P.M.+L.
3.17	3.58	3.60	3.72	3.91	4.25

[a] Any two means not underscored by the same line are significantly different.
** $P<.01$.

in the first trial. Peanut oil meal-corn rations supplemented with lysine and methionine, blood meal or fish meal produced gains that were comparable to soybean oil meal in the first trial. In the second trial, peanut meal-corn rations supplemented with lysine produced gains that were equal to the gains produced by lysine and methionine, blood meal or fish meal supplementation.

The lower response to lysine in trial 1 appears to be due to growth depression of the pigs when they reached the heavier weights. This is

believed to be due to the high level of lysine used. The growth pattern as shown in figure 1 indicates that these pigs made rapid early gains but slowed down as they reached heavier weights. This growth repression was largely overcome by feeding methionine along with lysine. Gessert

TABLE 4 EFFECT OF TREATMENT ON RATE OF GAIN, FEED EFFICIENCY AND CARCASS CHARACTERISTICS

Trial 2

Ration description	Basal	Plus alfalfa meal	Plus lysine	Plus lysine and methionine	Plus blood meal	Plus fish meal	Plus fish sol.
No. pigs	7	7	7	7	7	7	7
Initial wt., lb.	42	41	43	44	41	42	43
Final wt., lb.	191	190	203	192	190	201	193
Daily gain, lb.	0.95	0.95	1.52	1.41	1.42	1.53	1.24
Feed per lb. gain, lb.	4.13	4.21	3.35	3.61	3.41	3.30	3.80
Carcass length, in.	29.2	29.8	29.1	29.3	29.5	29.7	29.0
Backfat thickness, in.	1.35	1.20	1.38	1.53	1.33	1.41	1.40
Loin area, sq. in.	3.09	3.23	4.15	3.75	3.84	3.85	3.83

Analysis of variance

Source	df	Mean squares		
		Daily gain	Backfat	Loin area
Treatment	6	.438**	.074*	1.067**
Outcome	6	.200**	.077*	.440
Error	36	.033	.027	.186

Adj. mean daily gain [a]

P.M.+A.M.	P.M.	P.M.+F.Sol.	P.M.+L.+M.	P.M.+L.	P.M.+Bl.M.	P.M.+F.M.
.94	.97	1.24	1.38	1.50	1.50	1.51

Adj. mean backfat thickness

P.M.+A.M.	P.M.+L.	P.M.+Bl.M.	P.M.	P.M.+F.M.	P.M.+F.Sol.	P.M.+L.+M
1.23	1.27	1.34	1.39	1.42	1.42	1.55

Adj. mean loin area

P.M.	P.M.+A.M.	P.M.+F.Sol.	P.M.+L.+M.	P.M.+F.M.	P.M.+Bl.M.	P.M.+L.
3.09	3.24	3.33	3.75	3.84	3.84	4.15

[a] Any two means not underscored by the same line are significantly different.
** $P<.01$.

and Phillips (1956) showed that supplements of either lysine or methionine caused retardation of growth in dogs fed a low protein diet. When both of these amino acids were fed simultaneously, the growth repression caused by either one alone was overcome.

Adding alfalfa meal to corn-peanut oil meal rations had little effect on growth rate or carcass characteristics as shown in table 4. Fish solubles improved these rations, but at the level used in trial 2, they did not produce as rapid gains as the other supplements.

The extreme differences in slope of growth curves, when the average relationship of weight and daily gains are plotted by the method of least squares, (figures 1 and 2) indicate considerable differences in the effect of these rations on pigs at different weights. The extreme positive slopes of the growth curves for pigs fed peanut oil meal-corn rations indicate that as the pig becomes heavier he can make more efficient use of this

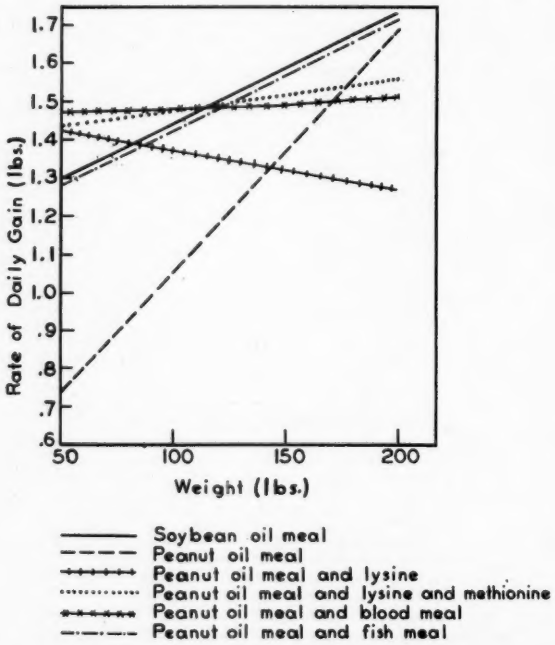

Figure 1. Effect of treatment on rate of gain at different weights. (Trial 1 calculated by least squares of weight and daily gain at two week intervals.)

ration. This would seem to indicate a decrease in lysine need as the pig grows older. The negative slope of the growth curve of pigs on a high level of lysine, figure 1, indicates that light pigs may need high levels of this amino acid while heavy pigs cannot maintain a rapid growth rate when used at this level, without methionine, as used in this lot. These postulated variations in lysine requirements are in line with reported results of Hutchinson *et al.* (1957). These workers estimated a lysine requirement of 0.9% of the ration for pigs 2 to 6 weeks of age while 0.5% lysine was adequate for weanling pigs. Brinegar *et al.* (1950) showed that level of protein also influenced lysine requirement.

Examination of the carcass data, tables 3 and 4, shows that pigs fed corn-peanut oil meal rations had smaller loin eye areas while pigs receiving lysine alone had the largest. The differences in loin eye area of pigs receiving lysine supplementation and those receiving lysine and methionine were statistically significant only in the first trial.

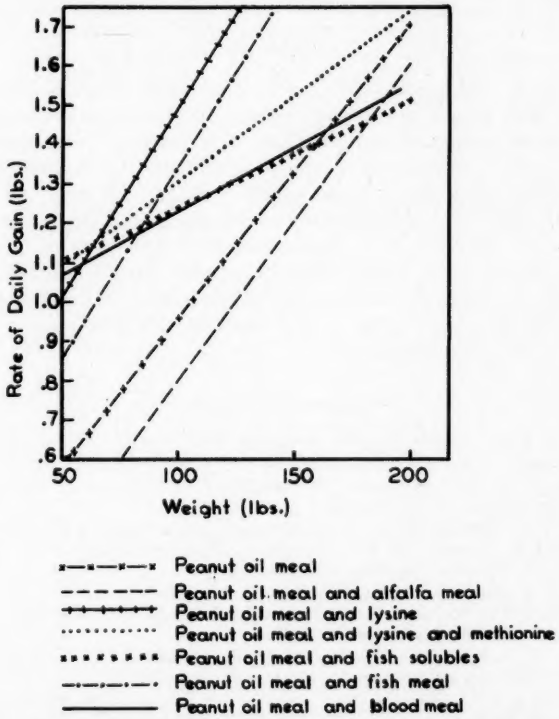

Figure 2. Effect of treatment on rate of gain at different weights. (Growth pattern calculated by least squares of daily gain at two week intervals.)

It was thought at the end of the first trial that these differences in loin areas might have been due to difference in rate of gain at different periods, i.e., growth pattern. This would be in line with the work of McMeekan (1940) who demonstrated that pigs fed at a high plane of energy followed by a low plane produced larger muscles than pigs fed in the opposite way. The pigs in the second trial where less lysine was used exhibited different growth patterns, however, while the loin eye size showed the same trends. This indicates that quality of protein in the ration affected the muscling

in carcasses of these pigs. It also hints that lysine added without methionine increased the size of the loin muscle.

Consistent effects of these rations on carcass length were not apparent. There was no difference in backfat thickness between lots in the first trial while the average backfat thickness in the second trial appeared to be related to the rate of daily gain.

Summary

Two trials were conducted to determine whether supplementing peanut oil meal with lysine, lysine and methionine or natural sources of these amino acids, namely, blood meal and fish products, would make this protein feed a satisfactory supplement to corn for growing-fattening swine. These supplements, when added to peanut oil meal-corn rations, produced highly significant improvements in rate of gain and muscle development. The data show that proper levels or balance of these amino acids is important. It appears that lysine may have a specific effect on loin area. The growth patterns may possibly account for differences in loin areas. The growth patterns also show the effect of these treatments on pigs at different weights.

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PHYSIOLOGICAL RESPONSES TO INSULIN-INDUCED STRESS IN OSTEODYSTROPHIC DWARF, DWARF CARRIER AND NORMAL BEEF CATTLE

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THE attempts to characterize the fundamental pathological physiology of the hereditary osteodystrophic or "snorter" dwarf have been generally unsuccessful (Crenshaw and Turner, 1954; Fransen and Andrews, 1958; Marlowe *et al.*, 1954; Cornelius *et al.*, 1956). Preliminary reports (Foley *et al.*, 1956), however, suggested a differential leucocyte response to insulin-induced hypoglycemia in normal [2] cattle, but not in a group of dwarf and dwarf carrier animals. Cornelius *et al.* (1956) also reported differences in differential white blood cell counts between apparently homozygotic normal and "snorter" dwarf cattle. These findings suggested that adrenal function may be impaired in the bovine dwarf and thus stress may be used to detect this impaired function (Selye, 1955). The availability at this station of a number of dwarf, dwarf carrier, and apparently normal animals made it possible to initiate a study to determine certain effects of insulin stress.

Experimental

The animals used in these experiments were Herefords and included "snorter" dwarfs and known carriers of the dwarf gene originally from a single ranch source. The animals presumably free of the dwarf gene came from a herd in which there has been no incidence of dwarfism to date. The experimental animals were of varying ages ranging from 9 months to 8 years of age. All of the animals were maintained on comparable diets and care was taken during experimental treatment to avoid undue excitement of the animals. Within a given experiment, animals of similar ages were compared.

Venous blood was used in the various analysis and was collected in test tubes containing an anticoagulant. All of the analyses were carried out as quickly as possible following the blood collections.

Nelson's method (Nelson, 1944) was used for the determination of blood glucose levels before and at intervals following the intravenous injection

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[2] For purposes of ease of statement in this report, the term "normal" will be used to designate cattle thought to be free of the dwarf gene, and "dwarf carrier" or "carrier" to designate a heterozygote identified by parentage of a dwarf.

of 0.8 unit of crystalline zinc insulin per kg. of body weight into 8 dwarf and 12 normal animals from 9 to 24 months of age. Sodium fluoride served as the anticoagulant in these studies.

The experiments on the effect of insulin stress on the blood leucocyte picture involved two major studies, one conducted in April with 8 dwarf, 9 dwarf carrier, and 10 normal cows and a second in July with 12 dwarf carrier and 12 normal females. The animals used in these studies were mature females ranging from 3 to 8 years of age.

The first blood sample was drawn in test tubes containing dipotassium ethylenediaminetetraacetate (EDTA) as the anticoagulant. Crystalline zinc insulin (0.8 unit per kg. body weight) was injected immediately and

TABLE 1. STRESS EFFECTS OF INSULIN ON BLOOD GLUCOSE

Animal classification	No. of animals		Period of stress				
			0 hr.	½ hr.	1 hr.	2 hr.	4 hr.
			Spring 1956				
Normal	12	Av.[a]	54.4	28.8	28.0	28.9	36.7
		S.D.[b]	5.4	31.2	7.9	6.4	7.2
Dwarf	8	Av.	55.5	35.0	35.0	34.6	36.5
		S.D.	4.6	16.3	14.9	12.4	6.2
			January 1958				
Normal	2	Av.	43.0		20.0	19.0	17.0
		Range	41–45		18–22	17–21	14–20
Dwarf carriers	3	Av.	81.0		63.0	56.0	46.3
		Range	78–83		53–70	49–65	37–52

[a] Glucose, mg. per 100 ml. blood.
[b] Standard deviation.

subsequent blood samples were drawn one hour and two hours after the insulin injection.

Total white cell counts and blood smears for differential white cell counts were made as quickly as possible after each blood collection. For total white cell counts 0.1 N HCl was used as the diluent, and Wright's Stain was used for the differential cell counts.

Amino acid determinations were made by microbiological assay techniques (Steele *et al.*, 1949) on protein-free filtrates of plasma prepared from blood collected at the same time as the blood for the other analysis from 9 dwarfs and 8 normal animals from 1 to 2 years of age. Acidometric measurements were used with *Leuconostoc mesenteroides* P-60 as the test organism for glycine, glutamic acid, and histidine determinations.

Results and Discussion

Blood Sugar. In the present investigations the effect of insulin on the blood sugar level was tested in 8 dwarf and 12 normal animals from 9 to 24 months of age. The large variation in response made it difficult to characterize the hypoglycemic response to insulin in either group of

animals. The average values (Spring 1956) for both groups of animals (table 1) indicate little if any difference in response between dwarf and normal animals when based on the effect of insulin-induced stress during a 4-hour period.

An experiment carried out in January, 1958, (table 1) with three dwarf carrier and two normal animals 3 to 8 years of age, indicated a similar pattern of response occurred in these animals. The initial blood sugar levels of the dwarf carrier animals were higher than those of the normal animals. Other than being at a higher level, the response of the dwarf carrier cows closely paralleled that of the normal cows. A somewhat poorer

TABLE 2. EFFECT OF INSULIN STRESS ON LEUCOCYTE COUNTS

Cells	Hr. after insulin	April 1957			July 1957	
		Normal	Carrier	Dwarf	Normal	Carrier
		Cells/mm³ blood × 10^{-3}				
Total leucocytes	0	8.64(1.28)[a]	8.74(1.84)	10.58(1.44)	9.09(2.09)	8.26(1.77)
	1	8.21(2.28)	9.76(2.51)	11.75(2.08)	9.33(1.76)	9.58(2.52)
	2	8.97(1.75)	12.44(2.46)	13.87(1.53)**	10.17(2.17)	10.02(2.19)
Neutrophiles	0	2.01(0.80)	1.90(1.05)	2.30(1.02)	1.64(0.64)	1.14(0.66)
	1	1.92(0.70)	2.85(1.75)	5.59(1.44)**	1.92(0.67)	2.59(1.19)
	2	2.03(0.54)	3.20(2.35)	4.42(1.12)**	2.56(1.19)	3.05(1.22)
Eosinophiles	0	0.93(0.33)	0.92(0.42)	0.62(0.26)	0.93(0.78)	0.63(0.56)
	1	0.84(0.53)	0.92(0.44)	0.62(0.33)	0.59(0.37)	0.60(0.33)
	2	0.93(0.57)	0.64(0.33)	0.58(0.50)**	0.64(0.48)	0.56(0.34)
Lymphocytes	0	5.44(1.16)	5.63(0.80)	7.63(0.64)**	5.94(0.79)	6.06(1.26)
	1	5.22(2.06)	5.88(1.25)	7.53(0.93)**	6.27(1.08)	5.95(1.63)
	2	5.38(1.56)	5.97(1.04)	8.21(1.09)**	6.02(1.03)	5.82(1.59)

[a] Mean±Standard deviation of the mean in parenthesis.
** Significantly different from values of normal animals ($P<0.01$).

condition of the dwarf carrier cows and the fact that they were more excitable than the normal animals used in the experiment may explain the high sugar levels observed in these animals. The minimum blood glucose level obtained in response to insulin seems more of a characteristic of the blood sugar level than the genetic propensity for dwarfism.

Blood Leucocytes. The results of studies of the total leucocyte or white cell count initially or after the injection of insulin (table 2) indicated that a pattern of response might be attributed to a specific group of animals, but there was also considerable individual variation within each group. Thus it was not possible to classify an animal in one group or the other on the basis of this test under these conditions. Statistically, however, a highly significant difference ($P<0.01$) was found between the total number of leucocytes in a group of 8 mature dwarf and 9 mature dwarf carrier females and the number in 10 mature normal cows in the April tests. Little or no change in total leucocyte count occurred in the apparently normal animals while a significant augmentation of total leucocytes appeared in the dwarf and the dwarf carrier animals during the 2-hour, post-injection period.

TABLE 3. CHANGES IN NEUTROPHILE COUNTS TWO (2) HOURS AFTER INSULIN

April 1957						July 1957			
Normal		Carrier		Dwarf		Normal		Carrier	
Animal no.	Count	Animal no.	Count	Animal no.	Count	Animal no.	Count	Animal no.	Count
106[a]	272	205[a]	3485	16	2047	106[a]	—1089	205[a]	3367
113[a]	812	209[a]	721	99	3793	113[a]	677	209[a]	2263
28	—145	224	4347	BE	1423	263	120	204	2850
89	—892	223	8870	4	—753	135	1218	213	3469
1442	1386	217	3295	E30	4110	1	580	219	2129
28T	1049	213	4824	E10	4919	38	1079	217	1930
B73	—658	303	2852	307	3549	51	146	305	711
B 6	—366	220	2316	6	820	58	2486	216	—11
B53	529	211	2447			143	1137	207	2570
B70	918					F44	2789	224	2472
						149	—298	301	839
						125	2102	206	334
Average	296		3684**		2489**		912		1910
Standard deviation	773		2283		1926		635		1172

[a] Animals tested in both experiments.
** Significantly different from values of normal animals ($P<0.01$).

It may be seen (table 2) that the total number of neutrophiles remained relatively constant in the normal animals, whereas the dwarf and dwarf carrier animals show a marked increase in neutrophiles. When the variance of the total number of neutrophiles was analyzed, a significant ($P<0.01$) hour by group interaction was found between the carrier and normal animals and between the dwarf and normal animals.

When the changes in the numbers of neutrophiles (table 3) were calculated and analyzed, a highly significant ($P<0.01$) difference was evident between the normal and the dwarf or dwarf carrier cows for the period from zero to 2 hours after the insulin injection. Further examination of the individual data in table 3 shows that, although statistically significant, the differences in the change in neutrophiles could not be used as the sole basis for a blood test to detect dwarf carrier animals. Overlap of values occurs so as to prevent the classification of several animals as dwarf, carrier or normal.

The average number of eosinophiles and lymphocytes remained relatively constant throughout the experiment, the level in the dwarfs for both types of cells being significantly higher ($P<0.01$) than in the carriers or normal animals. Thus the increase in total white cell count in the dwarf and carrier animals was accounted for by the increase in neutrophiles.

The results of the July study (table 2) indicate a response in the normal and carrier animals similar to that observed in the April experiment. Although statistical treatment of the data failed to indicate significant statistical differences, the greatest increase was again noted in the neutrophiles.

The eosinophiles decreased slightly in both groups of animals and the lymphocytes remained relatively constant.

In the comparison of the change in number of neutrophiles from zero to 2 hours (table 3), a larger average increase in the normal animals was shown in July than was apparent in April and a greater amount of overlap of values was observed. However, the neuthophilic response of the carriers was still greater than that of the normal animals.

The findings of Foley *et al.* (1956) in tests of the tolerance of certain animals to insulin, indicated very little response in the dwarf animals when white blood cell counts were used as a measure of the stress; whereas, the normal animals give a rapid and extreme increase in what were first described as "white cells" but later were suggested to be unhemolyzed erythrocytes or platelets (Lasley, 1957). Massey *et al.* (1956) reported an increase in the percent of neutrophiles in the normal animals in these experiments. Blood sugar levels reported by Foley *et al.* (1956) indicated a more rapid drop in blood sugar, and to a lower level, in dwarfs and a delay in its return to a normal level when compared to the normal animals.

The results of the present study seem to contradict the earlier work of Massey *et al.* (1956) and Foley *et al.* (1956) which indicated the greatest neutrophilia was in the normal animals. However, the dwarf and

dwarf carrier animals used in the present experiments were related and originally from the same ranch source. The normal and the dwarf and dwarf carrier animals were maintained in separate enclosures and therefore under somewhat different environmental conditions. Thus the responses to insulin may have had little relationship to the dwarf character.

Free Amino Acids in Plasma. Microbiological assay of the plasma-free glutamic acid, glycine, and histidine was also made in conjunction with these studies on 9 dwarfs and 8 normal animals 12 to 24 months old. In table 4 the initial values for these amino acids are shown to be about the same in both groups of animals. These values were diminished after insulin injection but the changes were of essentially the same magnitude in both groups of animals.

TABLE 4. PLASMA AMINO ACIDS BEFORE AND 5 HOURS AFTER INSULIN INJECTION

Time	Animal classification	Glutamic acid	Glycine	Histidine
		mg./100 ml.	mg./100 ml.	mg./100 ml.
Before insulin injection	Normal[a]	17.0(7.20)[c]	30.6(4.53)[c]	9.6(2.65)[c]
	Dwarf[b]	17.4(3.33)	30.4(2.10)	11.5(1.39)
5 hours following insulin injection	Normal[a]	5.9(4.33)	23.0(5.97)	8.3(0.93)
	Dwarf[b]	6.3(2.36)	23.5(5.62)	8.9(2.04)

[a] Eight normal animals.
[b] Nine dwarf animals.
[c] Mean ± Standard deviation of the mean in parenthesis.

Summary

In a series of experiments the effect of insulin on levels of the blood glucose and certain plasma-free amino acids of dwarf and normal animals failed to result in a differential response in these animals.

In two studies of insulin-induced stress involving 8 dwarf, 20 dwarf carrier and 22 presumably normal cows, an apparent differential response was observed when considering the change in the total number of neutrophiles from zero to 2 hours after the insulin injection, the greater increase being in the dwarf and carrier animals.

These data suggest a physiological difference between the groups of animals. However, the differences observed in the present studies cannot be considered as a basis for a test for the dwarf gene until verified by other experimentation.

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ESTIMATION OF THYROID SECRETION RATES IN DAIRY GOATS AND MEASUREMENT OF I^{131} UPTAKE AND RELEASE WITH REGARD TO AGE, PREGNANCY, LACTATION, AND SEASON OF THE YEAR [1]

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ALTHOUGH experimental alterations in thyroid function have been shown to influence all of the important productive functions of livestock (Blaxter *et al.*, 1949; Sykes *et al.*, 1953), it has not been feasible until recently to determine quantitatively the level of thyroid secretion and its normal physiological variations. A thyroxine substitution method that permits determination of thyroid secretion rate of individual animals was first reported for the sheep by Henneman *et al.* (1952, 1955) and confirmed and extended by experiments in rats (Reineke and Singh, 1955). Further studies in sheep have been reported by Singh *et al.* (1956) and in dairy calves by Lewis *et al.* (1955), Pipes *et al.* (1957) and Lodge *et al.* (1957).

In the present study the thyroxine substitution method for determining thyroid secretion rate was adapted to the dairy goat; and, data are presented on the physiological variations observed under our conditions. Comparisons are also made between thyroid secretion rate and thyroidal I^{131} uptake and output rate in the same animals.

Experimental Procedure

Female dairy goats of mixed breeding were divided into groups according to age: Immature (8 months), young (2 years) and aged (4–6 years). These groups were further divided into pregnant or non-pregnant and lactating or non-lactating animals. Experiments were conducted at various times of the year so that data were obtained for each of the four seasons. Environmental temperature was not controlled except for supplementary heat during cold weather when the animals were in the barn. Roughage consisted of pasture during the summer and third-cutting alfalfa hay during the winter. This was supplemented throughout the year with a dairy concentrate mixture (20% protein) that was stated by the manufacturer to contain 0.00015% iodine.

To facilitate the measurement of thyroidal radioactivity and permit good duplication of geometry, the restraining rack shown in figure 1 was designed

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and constructed. The front panel of the rack, to which the head stall is attached, can be adjusted vertically to accommodate animals of varying stature. The head stall is adjustable forward or backward to fit animals

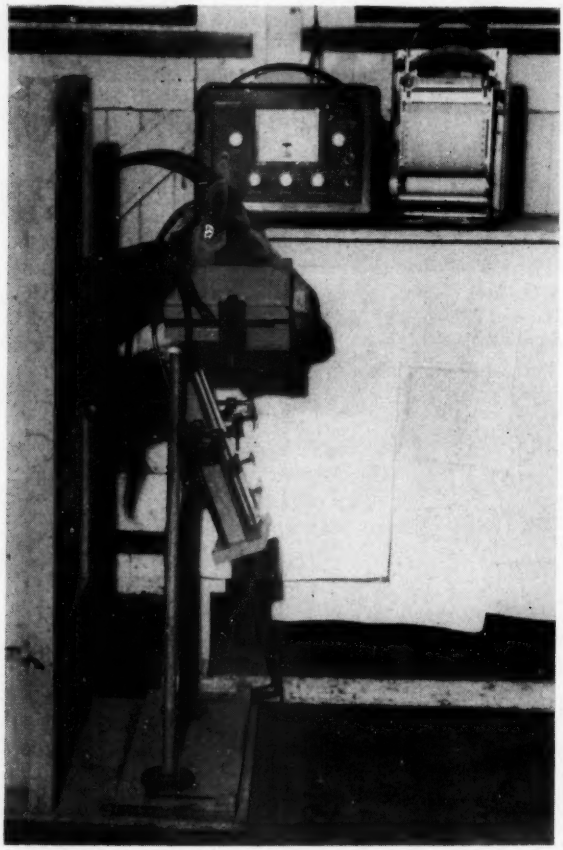

Figure 1. Restraining rack and counting equipment used to measure thyroidal radioactivity in the goat.

with necks of varying length. The scintillation tube stand and holder can be adjusted through three dimensions to allow accurate focusing on the thyroid region. Attached to the tube holder, there is also an adjustable spacer to allow for duplication of the same distance between the tube face and animal neck in repeated counts. The spacer was set to maintain a counting distance of 5 to 10 cm., depending on the level of thyroid radio-

activity found in a given determination. The same distance selected for the initial count was then used for all subsequent counts in that animal. Body background counts were taken at similar geometry over the outer portion of the thigh. The counts were recorded graphically on an Esterline-Angus recorder connected to a count rate meter and scintillation detector. Excellent repeatability of counts was obtained with this system. Before further computation, the counts were corrected for background and physical decay.

A tracer dose of 50 μc of carrier-free I^{131} was injected subcutaneously in the shoulder region of each goat. Thyroid radiation was determined daily until peak uptake had occurred; thereafter, counts were made every third day until an output curve had been established. L–thyroxine injections were then started at a low dose level and increased every third day by an appropriate increment. An external thyroid count was taken every third day, coinciding with the end of each period on a given thyroxine level, so that the effect of each dosage increment upon thyroidal I^{131} output rate was determined. The degree of inhibition of output was measured by calculating the percent of last previous count. The end-point used was that amount of exogenous L-thyroxine needed daily to prevent I^{131} output, or that point where the radioactivity count remains at 100% of its preceding count.

In each experiment, aliquots of the I^{131} solution used for injection were prepared in duplicate and were counted at the same distance employed for the thyroid counts to permit computation of thyroidal I^{131} accumulation as percent injected dose.

To measure the thyroid secretion rate of cattle by the method employed here, it has been necessary to administer thiouracil to block iodine uptake. In this way, a sufficiently rapid output rate of I^{131} is obtained so that the extent of inhibition of output by varying doses of thyroxine can be precisely determined (Lewis *et al.*, 1955; Pipes *et al.*, 1957; Lodge *et al.*, 1957). Consistent values were obtained in goats without thiouracil. Therefore, an experiment was included to compare the thyroxine secretion value in normal and thiourcilized goats. Thiouracil was given orally twice daily at 12-hour intervals at the rate of 0.1 mg. per kg. body weight.

In one experiment, blood and milk samples were taken at intervals during fifty hours after the I^{131} injection. Radioactivity of 3-ml. samples of milk or blood serum was determined with a scintillation well counter and laboratory scaler. Standards were prepared by adding an aliquot of the I^{131} injection solution to control milk and serum, respectively.

Results and Discussion

I^{131} Turnover and Thyroid Secretion Rate in the Normal Goat. A typical I^{131} turnover curve for the goat is shown in figure 2. Maximum thyroidal I^{131} uptake occurred by the 4th day after I^{131} injection. A straight line was fitted to the points in the middle portion of the curve by the method of

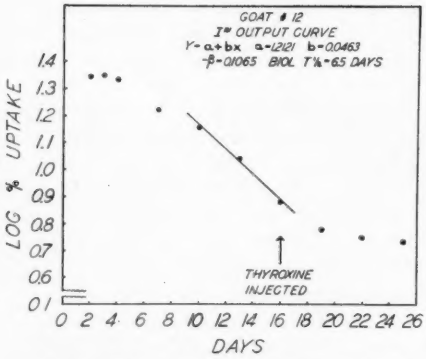

Figure 2 Typical I^{131} turnover curve for the goat. The last three points show the inhibition of I^{131} output by progressively increasing doses of thyroxine.

least squares and the output constant $(-\beta)$ and biological half-time $(t\ 1/2)$ was computed as described by Wolterink (1953).

The progressive inhibition of I^{131} output after thyroxine injections were started on day-16 is clearly shown. Each day's count in this segment of the curve was expressed as a percentage of the previous count, plotted

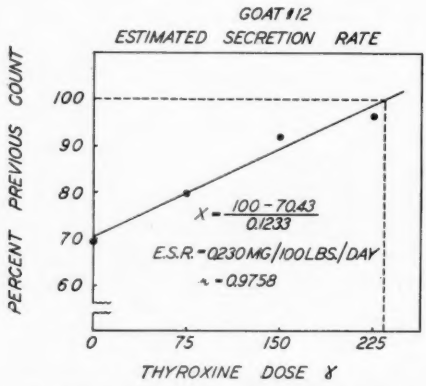

Figure 3. Method of estimating thyroid secretion rate. The thyroxine dosage equivalent to the point where the regression line reaches 100% previous count is the estimated thyroid secretion rate.

against thyroxine dose (fig. 3), and a straight line was fitted to the points by the least squares equation:

$$y=a+bx \tag{1}$$

where y=percent previous count, and x=thyroxine dosage.
The values for a and b were 70.43 and 0.1233, respectively. By rearrangement, the above equation becomes:

$$x=\frac{y-a}{b} \tag{2}$$

Then, taking y as 100 and substituting the determined constants, a and b, in the equation,

$$x=\frac{100-70.43}{0.1233} \tag{3}$$

Solving this we find x, the estimated thyroxine secretion rate, to be 0.230 mg. L-thyroxine per 100 lb. body weight daily. Satisfactory proportionality between thyroxine dose and response was shown by the highly significant correlation coefficient of 0.9758. The average correlation between dose and percent preceding count obtained in 101 individual thyroid secretion rate determinations by this method in normal goats and 4 in thiouracilized goats was 0.944 with a standard error of 0.0301.

Figure 4 shows average output curves for two groups of 2-year-old goats, one group of four normal and the other containing six thiouracil-treated animals. The output half-time for the normal is 11.07 days and for the thiouracil group 7.2 days. Thyroid secretion rates were computed

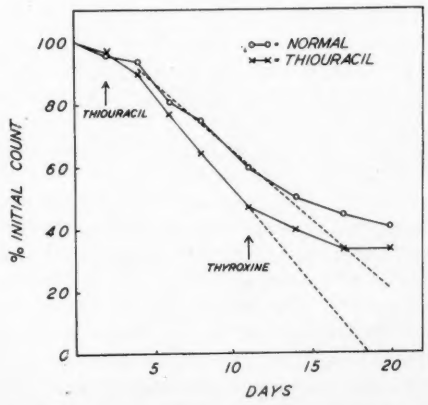

Figure 4. Thyroidal I^{131} turnover curves of normal compared to thiouracil-treated goats.

for the individual animals as already described. When the mean secretion rate of 0.338±0.015 mg./100 lb./day obtained for the young, thiouracilized goats (table 1) was compared to that calculated for the young, normal animals (0.336±0.018) no significant difference was found.

TABLE 1. SUMMARY OF MEAN VALUES OBTAINED FOR I^{131} OUTPUT HALF-TIME ($T_{½}$), THYROIDAL I^{131} UPTAKE AND THYROID SECRETION RATE FOR GOATS OF THREE AGE GROUPS AT VARIOUS TIMES OF THE YEAR

Time and age group	Number	$T_{½}$, days	48-hr. uptake, % of inj. dose	Thyroid secretion[a]	Mean T., ° F. Monthly	Min.	Max.[c]
February							
Aged	4	7.25 (6.77–8.37)[d]	16.00 (4.44–28.35)[d]	0.187±0.016[b] (0.128 – 0.245)[d]	29.1	36.8	21.3
Young	6	7.33 (5.58–8.93)	20.50 (11.85–48.71)	0.325±0.019 (0.267 – 0.407)			
May							
Aged	5	7.27 (6.30–8.76)	31.90 (20.3–46.1)	0.199±0.024 (0.109 – 0.243)	57.0	67.3	46.6
Young	4	6.70 (5.90–8.10)	32.40 (17.7–48.3)	0.278±0.036 (0.190 – 0.361)			
July							
Aged	5	12.55 (8.48–15.89)	34.60 (14.5–55.9)	0.099±0.024 (0.050 – 0.161)	72.8	84.3	61.3
Young	4	10.69 (9.26–12.24)	28.73 (20.7–35.7)	0.177±0.013 (0.104 – 0.288)			
August							
Aged	5	10.35 (13.1–28.3)	18.90 (7.4–18.2)	0.197±0.033 (0.111 – 0.285)	69.8	81.4	58.2
Young	4	11.40 (10.15–12.16)	13.60 (8.5–23.3)	0.213±0.017 (0.172 – 0.244)			
Immature	5	8.58 (5.04–12.50)	20.30 (4.0–40.6)	0.262±0.051 (0.172 – 0.441)			
October							
Aged	8	10.70 (8.37–16.46)	11.40 (2.4–15.8)	0.243±0.03 (0.155 – 0.394)	49.6	60.2	39.1
Young	6	11.07 (8.12–13.50)	9.55 (1.5–13.5)	0.336±0.018 (0.245 – 0.362)			
Young (thiouracil)	4	7.20 (6.20–7.97)	6.70 (3.9–9.8)	0.338±0.015 (0.308 – 0.502)			
Immature	4	10.32 (7.29–13.56)	16.20 (7.5–24.5)	0.403±0.037 (0.302 – 0.478)			

[a] Expressed as mg. L-thyroxine secreted daily per 100 lb. body weight.
[b] Standard error of the mean.
[c] Data supplied by the U. S. Weather Bureau Station, East Lansing, Mich.
[d] Figures in parentheses are the range of values in each case.

The difference in t ½ values between normal and thiouracil-treated animals, even though their average secretion rates were not different, can be attributed to two causes: (1) In the non-thiouracilized animals, a certain amount of recycling of I^{131} as well as I^{127} normally takes place. This would be reflected in a longer t ½. (2) The second, and more important cause, is the difference in composition of the thyroid iodine pools over a period of time. In the thiouracilized animal, the organification of iodine is blocked and, therefore, this iodine pool would decrease over a period of time. However, the proportion of non-radioactive iodine to radioactive iodine in the gland would remain constant and the thyroid hormone released from the

gland would, therefore, have the same specific activity at one instant as at a later time. In the normal animal, iodine uptake and organification is unimpeded. The size of the iodine pool would remain relatively constant over a short period of time, but its composition with regard to I^{127} and I^{131} would be changing. The specific activity of the hormone leaving the gland would become increasingly smaller because of the dilution effect of I^{127}. This also would be reflected in a longer t ½. In either case, although there is a difference in t ½ values, the same amount of hormone would be expected to leave the gland daily, as long as there is sufficient in store to meet the physiological requirement. Since the method employed in this study is one of substitution that measures the daily thyroid hormone output needed to maintain the thyroid-pituitary balance, similar values should be obtained by these two approaches. In view of the close agreement obtained, all subsequent determinations were made without using a goitrogenic agent.

Effect of Age and Season on Thyroid Secretion Rate and I^{131} Turnover. Pronounced seasonal rhythms of thyroid secretion rate were found in both young and aged goats (table 1). The change from high activity in fall, winter, and spring to low activity in summer is similar to that reported for chickens (Reineke and Turner, 1945; Schultze and Turner, 1945) and for sheep (Henneman *et al.*, 1955). Lodge *et al.* (1957) reported somewhat lower thyroid secretion rates in dairy heifers during August and September than in May. Premachandra *et al.* (1958) observed about a 3-fold decline in the thyroid secretion of cattle in summer as compared to winter under the climatic conditions prevailing in Missouri. They also point out "that an increasingly warm environment is a greater stimulus to a reduction in thyrotropic hormone secretion than is a gradually colder environment for increased thyrotropic activity".

The sharp decline in thyroid secretion rate of goats during July, the warmest period for which values were obtained in the present experiments, suggests a critical high temperature beyond which thyroid function is markedly depressed. In a varying environment, the critical temperature is probably influenced by both the temperature level and the duration of exposure to high temperatures. In view of the wide diurnal variations observed (table 1), a precise value for this critical temperature cannot be determined from these data.

Compared with sheep, goats of similar age, weight, and sex have a higher rate of thyroid activity throughout the year. The mean secretion rate for 2-year-old goats ranged from a high of 0.336 ± 0.018 mg. L-thyroxine per 100 lb. body weight during October to a low of 0.177 ± 0.013 mg. in July. In the aged group, the values ranged from a high of 0.199 ± 0.024 mg. in May to 0.099 ± 0.024 mg. in July. The secretion rate for both age groups in July was significantly lower ($P < 0.01$) than for any other month studied except August. The mean thyroid secretion rate of aged goats was lower than that of the young group at all periods studied, but the difference was

statistically significant only during February, July, and October. The failure to attain significant differences in May and August is probably due to fluctuations in the environment during these months. The larger standard errors found for these measurements support this interpretation. No significant difference was observed between the mean secretion rates of the immature and young goats during either August or October. However, the immature animals had a higher average rate during both experiments. Similar findings of variations in age groups have been reported for other species. Using the protein-bound iodine technique, Long *et al.* (1952) observed differences due to age in cattle. Henneman *et al.* (1955) reported a significant decline with age when 2-year-old ewes were compared to

TABLE 2. THE VALUES OBTAINED FOR COEFFICIENTS OF CORRELATION (r) WHEN 48-HOUR PERCENT UPTAKE AND OUTPUT HALF-TIME IS COMPARED WITH THYROID SECRETION RATE

	February		May		July		August		October		Entire Year	
Item	r	D.F.[a]	r	D.F.	r	D.F.	r	D.F.	r	D.F.	r	D.F.
Uptake vs. Secretion rate	0.1939	9	—.0143	18	0.3670	17	0.5373*	24	0.3262	17	0.067	89
T ½ vs. Secretion rate	—.0487	9	0.5624*	19	0.2090	17	—.2865	24	—.0285	17	—.1685	90

[a] Degrees of freedom.
* Probability=0.01.

4-year-old ewes. Similar results were reported in rats by Wilansky *et al.* (1957).

The rather extensive use of either I^{131} uptake or t ½ as indices of thyroid function is based upon the assumption that thyroidal iodine content will remain constant. If this ideal situation were to hold true, iodine uptake at any time would equal its output; I^{131} uptake would vary directly and t ½ inversely with thyroid secretion rate. Under the conditions of our experiments, the relationships are not nearly this direct and simple. During the period from February to July, the t ½ for both aged and young groups increased markedly, as would be expected with the decrease in thyroid secretion rate. During the same time, however, I^{131} uptake showed a pronounced increase (table 1). From July to October, t ½ showed little change while thyroid secretion rate increased and I^{131} uptake decreased. A similar increase in I^{131} uptake in calves during the summer was reported by Lodge *et al.* (1957). These findings are consistent with the marked summer increase in iodine content of cattle and sheep thyroids reported by Seidell and Fenger (1913).

In agreement with the results already described, no consistent correlation was found between thyroid secretion rate and I^{131} uptake or output ½ time (table 2). The overall correlation between thyroid secretion and I^{131} uptake for the entire year was only 0.067, a value that is statistically

nonsignificant. When the data were compared within months, the only significant correlation between thyroid secretion rate and uptake was the value of 0.540 obtained for August ($P<0.01$). A nonsignificant correlation of −.168 was obtained for thyroid secretion rate versus t ½ for all of the data. In the comparisons within months, the only apparently significant correlation of 0.562 for May is the opposite sign than would be expected

TABLE 3. SUMMARY VALUES OBTAINED FOR OUTPUT HALF-TIMES, THYROIDAL I^{131} UPTAKE AND THYROID SECRETION RATES FOR AGED AND YOUNG LACTATING, PREGNANT AND NON-PREGNANT GOATS

Month and group	Number	T½, days	48-hr. uptake, % inj. dose	Thyroid secretion[a]
February				
Pregnant	5	7.06	20.47	0.262±0.026[b]
		(5.69–7.93)[c]	(4.44–48.71)[c]	(0.175 – 0.321)[c]
Non-pregnant	5	7.53	16.97	0.277±0.050
		(5.58–8.93)	(4.25–29.09)	(0.128 – 0.407)
May				
Aged lactating	4	7.59	14.00	0.188±0.053
		(6.27–8.94)	(5.4–22.1)	(0.132 – 0.230)
Young lactating	7	8.96	15.20	0.263±0.030
		(5.85–14.56)	(9.2–19.6)	(0.166 – 0.380)
July				
Aged lactating	3	10.43	7.70	0.050±0.016
		(10.17–10.95)	(3.6–13.7)	(0.031 – 0.082)
Young lactating	6	10.05	8.16	0.070±0.007
		(8.10–15.07)	(5.8–10.4)	(0.042 – 0.091)
August				
Aged lactating	4	10.33	9.50	0.121±0.040
		(7.29–14.20)	(1.6–18.3)	(0.061 – 0.237)
Young lactating	7	13.40	6.90	0.177±0.040
		(11.00–15.30)	(4.8–10.1)	(0.122 – 0.298)

[a] Expressed as mg. L-thyroxine secreted daily per 100 lb. body weight.
[b] Standard error of the mean.
[c] Figures in parentheses are the range of values in each case.

if a consistent relationship between t ½ and thyroid secretion rate were maintained. A similar lack of agreement between I^{131} uptake or t ½ and thyroid secretion rate were reported for cattle by Premachandra *et al.* (1958).

The method employed for determining thyroid secretion is based upon hormone substitution, a classical procedure in physiology. Values are derived independently of the rate constants for I^{131} turnover. All evidence to date indicates that they give a valid estimate of thyroid activity. The lack of consistent agreement between either I^{131} uptake or t ½ and thyroid secretion rate indicates that the former two methods are of little value in assessing thyroid activity of animals exposed to normal environmental variations. In animals maintained in a controlled environment, where a "steady

state" of the thyroid is probably more nearly achieved, I^{131} turnover rate provides a fairly reliable index (Henderson, 1958).

Effect of Pregnancy and Lactation on Thyroid Secretion Rate and I^{131} Turnover. The mean thyroid secretion rate, expressed as mg./100 lb./day, for the pregnant animals was found to be 0.262 ± 0.026. For the non-pregnant animals a value of 0.277 ± 0.05 was obtained (table 3). When these mean values were subjected to the "student t" test no significant difference was found. This agrees with the results reported for sheep by Henneman *et al.* (1955) and for rats by Monroe and Turner (1948).

Thyroid secretion rates of lactating goats taken in May, July, and August showed seasonal variations similar to those already described for open

TABLE 4. CORRELATION BETWEEN MILK YIELD OF LACTATING GOATS AND THEIR THYROID SECRETION RATE AND THYROIDAL I^{131} UPTAKE

Month	Group	No.	Mean thyroid secretion [a]	Mean monthly milk prod., lb.	Thyroid secretion vs. milk yield, r	48-hr. uptake vs. milk yield, r
May	Aged	4	0.188	119.8	−.731	−.935*
May	Young	7	0.263	139.7	−.475	0.474
July	Aged	3	0.050	75.3	−.914	−.973*
July	Young	6	0.060	65.8	−.161	0.149
Aug.	Aged	4	0.121	57.5	−.930*	−.843
Aug.	Young	7	0.177	60.7	−.285	−.617

* $P < 0.05$.
[a] mg. L-thyroxine daily per 100 lb. body weight.

goats. When these values (table 3) were compared with those of non-lactating goats of corresponding age and month (table 1), the lactating goats were lower in each case, although the difference was significant ($P < 0.01$) only in July. These results were quite unexpected and are at variance with previous studies in sheep (Henneman *et al.*, 1955). Monroe and Turner (1948) reported no difference in thyroid secretion rates of lactating and non-lactating rats studied by the goiterogen technique. However, Grosvenor and Turner (1958) have recently reported a significantly elevated thyroxine secretion rate in lactating rats as measured by the isotopic method.

A possible explanation for the apparent depression of thyroid secretion rate in lactating goats is provided by the comparative uptake of I^{131} by the thyroid and its secretion in milk.

As recorded in table 3, the mean percent of injected dose taken up by the thyroid in 48 hours for lactating aged and young goats, respectively, during the month of May was 14.00 and 15.20. The values for aged and young open animals during the same period (table 1) were 31.9 and 32.4 respectively. During July the values for aged and young milkers, respectively, were 7.7 and 8.16 as compared to 34.6 and 28.73 for aged and young

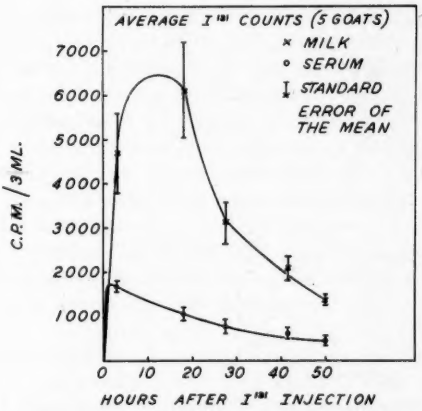

Figure 5. Comparative radioactivity of milk and blood serum at various intervals after a single injection of I^{131}.

open goats, respectively. In August the same relationship again prevailed, the values for the lactating animals being approximately 50% lower than those observed for open goats.

When thyroid secretion rates and milk production for the individual goats in each of the subgroups were compared, a consistently negative correlation was found (table 4). There was a similar negative correlation between milk yield and 48-hour uptake of I^{131}, although the only significant values were for the aged groups in May and July.

A direct comparison of the average I^{131} concentration in milk and blood serum of five goats is shown in figure 5. Within 3 hours after injection, the I^{131} concentration in milk was nearly three times that in serum. Eighteen hours after injection, the average ratio of radioactivity in milk to that of serum was 6.8:1. Milk to serum ratios for individual goats ranged from 2:1 to 15:1. During the first 50 hours, an average of 26.7% of the I^{131} injected was secreted into milk compared to 9.6% taken up by the thyroid (table 5).

Wright *et al.* (1955) reported that an average of 50% of the dose was secreted in the milk of goats during 7 days after I^{131} administration. One

TABLE 5. COMPARISON OF I^{131} RETENTION IN THYROID AND SECRETION IN MILK DURING A 50-HOUR PERIOD AFTER I^{131} INJECTION

Goat no.	11	15	16	18	19	Average
Percent I^{131} dose in milk	22.2	18.7	27.5	10.6	54.6	26.7
Percent I^{131} dose in thyroid	9.9	11.3	10.4	7.6	8.6	9.6

goat that secreted 45.3% of the dose in milk excreted an additional 40.7% in urine and 2.3% in feces. In contrast to the results in goats, Lengemann, Monroe, and Swanson (1955) reported that cows secreted in the milk only about 5% of an administered dose of I^{131} in 7 days. Lengemann and Comar (1956) stated that usually the amount of I^{131} in milk of cows paralleled that in blood and no concentration effect was noted. In view of the present findings, additional data on lactating cows would be of interest.

The reduced thyroid secretion rate of lactating compared with nonlactating goats as well as the negative relationship between thyroid secretion rate and milk yield does not mean that low thyroid activity favors good lactation. In fact, the well established decrease in lactation after thyroidectomy and the increase with thyroprotein feeding indicates that the opposite is true.

The high concentration of iodine in milk relative to its level in blood serum and the large absolute loss of iodine by this route, together with the continued elimination of iodine via the kidneys of lactating goats (Wright *et al.*, 1955) would hasten the elimination of any iodine present in the blood. This in turn could very well account for the pronounced decrease in thyroidal I^{131} uptake. If inadequate amounts of iodine for normal thyroxine synthesis are taken up, the end result would be a decrease in thyroxine secretion rate. Under the conditions of these experiments, lactation would tend to become a self-limiting process because of reduced thyroid function resulting from the udder-kidney-thyroid competition for available iodine.

Although the grain fed was supplemented with iodine, an analysis of the iodine content of the roughage was not obtained. Michigan is known to be a low-iodine area, so it is probable that the total iodine intake was minimal. This view is supported by the wide range in 48-hour uptake values (tables 1 and 3). Further experiments on a controlled iodine intake will be needed to determine whether the relationships observed here are generally applicable under other conditions.

Summary

The substitution technique for measuring thyroid secretion rate in individual intact animals was adapted to the dairy goat. Normal goats were found to have a sufficiently rapid thyroidal I^{131} output rate to permit application of the method without thiouracil administration. Thiouracil-treated goats had a more rapid I^{131} output rate, but their thyroid secretion rate as measured by the thyroxine substitution method was not significantly different from values found concurrently in normal goats.

In both young (2-year-old) and aged (4-to-6-year-old) goats, the thyroid secretion rate was high in the fall, spring, and winter, but declined to about one-half the winter level during July.

Comparisons between 8-month-old, 2-year-old, and 4- to 6-year-old

animals showed a progressive decline in thyroid secretion rate with increasing age.

The percent uptake of injected I^{131} by the thyroid showed no consistent correlation with thyroid secretion rate. However, there was a definite increase in uptake during the summer.

Thyroidal I^{131} output half-time ($t\ ½$) values were smaller in both young and aged groups during February and May than in July, August, and October. Again there was no consistent correlation with thyroid secretion rate.

On the basis of these comparisons, it was concluded that neither thyroidal I^{131} uptake nor output rate are reliable indices of thyroid function in goats exposed to normal environmental variations.

Both aged and young lactating goats had a lower thyroid secretion rate than nonlactating controls of similar age during each of the three months in which comparisons were made. Thyroidal uptake of I^{131} was only about one-half as great in lactating as in nonlactating animals. Within lactating groups, there was a negative correlation between milk yield and thyroid secretion rate and also between milk yield and I^{131} uptake. Determinations of I^{131} in milk and blood serum from five animals showed an average maximal concentration of I^{131} in milk that was six times as high as that in serum. During the first 50 hours after I^{131} administration, an average of 26.7% of the dose was secreted in milk and 9.6% retained in the thyroid. These data were interpreted to indicate that through the udder-kidney-thyroid competition for available iodine, a functional iodine deficiency was created, and this resulted in a reduced thyroid secretion rate.

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ABSTRACTS OF PAPERS PRESENTED AT MEETING OF THE SOUTHERN SECTION, A.S.A.P., FEBRUARY 2, 3, 4, 1959, MEMPHIS, TENNESSEE

RELATIONSHIP OF 120-DAY AND WEANING DAILY GAINS OF BEEF CALVES.

Joe W. High, Jr., H. J. Smith and C. S. Hobbs, *University of Tennessee, Knoxville.*

The data used in this study consisted of the daily gains from birth to 120 days and from birth to weaning of 744 beef calves at seven different locations for the years 1957 and 1958. Analysis of data was made on a within location, year, age of dam and sex basis. Correlations between daily gain from birth to 120 days and daily gain from birth to weaning for all locations were very consistent and highly significant. The pooled correlation within station, year, age of dam, sex and between the daily gains of calves for these two periods was 0.86 ($P<.01$). The regression of daily gain from birth to weaning on daily gain from birth to 120 days was 0.73. This high correlation indicates that daily gain from birth to 120 days would have a relatively high predictive value with respect to daily gain from birth to weaning. Cows which have calves with highest daily gains from birth to 120 days would, with few exceptions, have calves with the highest daily gains from birth to weaning. Repeatability estimates for daily gain from birth to 120 days and daily gain from birth to weaning were computed by intra-class correlation and by correlation between adjacent records of calves from the same cow.

FACTORS INFLUENCING WEANING WEIGHTS OF HEREFORD AND ANGUS CATTLE IN MISSISSIPPI.

J. H. Meade, Jr., J. C. Dollahon, J. C. Taylor, and C. E. Lindley, *Mississippi State University, State College.*

Data in this study were from records of grade Hereford and Angus herds located at Experiment Stations throughout Mississippi. Correction factors were determined in order to facilitate the construction of an index for an on-the-farm testing program. The average unadjusted weaning age was 245 days and the unadjusted weaning weight of Hereford and Angus calves combined was 444 lb. After being adjusted to a constant age of 205 days, the Angus male and female calves averaged 413.6 and 389.3 lb., and the Herefords 386.4 and 362.1 lb., respectively. Sex was adjusted for by multiplying the weight of female calves by 1.06. Correction factors for cows of 2, 3, 4, 11, and 12 years of age were 1.09, 1.09, 1.05, 1.03, and 0.96, respectively. The average birth weights for Angus and Hereford calves were 61.6 and 66.5 lb., respectively. Calving interval was 460.3 days for Angus cows and 412.5 for Hereford. Correlations between weaning weight and weaning grade were 0.36 and 0.40; between weaning weight and birth weight, 0.35 and 0.40; and between birth weight and weaning grade, (-) 0.07 and 0.11 in the Angus and Hereford herds, respectively. Heritability estimates obtained by paternal half-sib correlations were 99 and 100% for birth weight and 72 and 100% for weaning weight in the Angus and Hereford herds, respectively. Repeatability was found to be 35% for birth weight and 16% for weaning weight in the Angus herd and 28% and 42% in the Hereford.

VALUE OF PANGOLA HAY AND SILAGE IN STEER FATTENING RATIONS.

W. G. Kirk, F. M. Peacock, E. M. Hodges and J. E. McCaleb, *Range Cattle Experiment Station, Ona, Florida.*

Pangola hay and silage fed at three levels to yearling steers were compared in three dry-lot trials of 120, 127 and 120 days. The 96 steers of Brahman and Shorthorn

breeding with an average initial weight of 762 lb. were well grown but in thin flesh when placed on feed. Three lots in each trial were fed hay free-choice and three lots, silage. Cottonseed meal, 41%, was fed at the rate of 3 lb. daily per animal. Average daily ration other than cottonseed meal was, in pounds, as follows: Lot 1—16.4 hay; Lot 2—12.2 hay, 3.9 dried citrus pulp and 3.9 citrus molasses; Lot 3—8.4 hay, 7.7 pulp and 6.1 molasses; Lot 4—59.2 silage; Lot 5—37.9 silage, 3.9 pulp and 4.0 molasses; Lot 6—28.4 silage, 7.8 pulp and 5.8 molasses. Average daily gain for Lots 1, 2, 3, 4, 5 and 6 was 1.15, 1.86, 2.27, 1.29, 1.94 and 2.40 lb., respectively. Average TDN eaten per 100 lb. gain for Lots 1 to 6 was 780, 640, 618, 807, 627 and 604 lb. Lot 1 obtained 77% of its TDN from pangola hay; Lot 2—43%; and Lot 3—25%; and Lot 4 obtained 80% from pangola silage; Lot 5—44% and Lot 6—28%. Average initial slaughter grade for all lots was U. S. Utility and final grade was U. S. Low Standard for Lots 1 and 4, Low Good for Lot 2, High Standard for Lot 5 and Good for Lots 3 and 6.

EFFECTS OF METHODS OF PREPARATION OF CHICKEN LITTER ON ITS UTILIZATION BY BEEF CATTLE. Maurice L. Ray, *University of Arkansas, Fayetteville.*

Twenty yearling steers were individually fed three types of broiler house litter in a comparison with lespedeza hay as the roughage of a fattening ration. Cane bagasse (Serval) and oat straw litter were each fed in unground form, finely ground and medium ground to six steers. Six steers were fed unground lespedeza hay. One-half of the steers on each roughage were fed 9:1 corn-cottonseed meal mix plus 1 lb. vitamin A concentrate per ton. For the other half milo was substituted for corn. Two steers were fed unground rice hull base litter. The ground litter was dusty, and difficulty was experienced in getting steers on feed. During the initial 27-day adjustment period 12 of the 14 steers fed litter lost weight (av. 40 lb.). During the next 70-day period steers fed lespedeza hay, unground rice hulls and unground bagasse litter made satisfactory gains. ADG for all steers fed corn was essentially the same as those fed milo. For the last 42-day period all litter was pelleted. Intake and gains improved on the straw litter only. Two lb. of black strap molasses fed daily on top of the other feed did not improve intakes or gains.

COMPARATIVE ENERGY VALUES OF COASTAL BERMUDAGRASS HAY, PEANUT HAY AND ALFALFA HAY. P. F. Parks and W. B. Anthony, *Alabama Agricultural Experiment Station, Auburn.*

Three metabolism trials were carried out to compare the nutritive value of coastal Bermudagrass hay, peanut hay and alfalfa hay fed to yearling stocker steers. Measures of nutritive value were digestibilities of energy, dry matter, protein and cellulose, and dry matter intake. The first trial, in which coastal Bermudagrass and peanut hay were compared, gave the following results, respectively: digestible energy, 2142.9 and 1987.4 Cal./kg.; dry matter digestibility, 46.62 and 46.36%; protein digestibility, 46.65 and 52.90%; cellulose digestibility, 51.36 and 54.70%; and dry matter intake, 4.38 and 5.57 kg./day. In a second trial the coastal Bermudagrass and peanut hays were blended with concentrate. The mixtures fed contained 69% hay and 31% concentrates. The following results were obtained, respectively: digestible energy, 2443.4 and 2428.7 Cal./kg.; digestibility of dry matter 56.04 and 53.42%; protein, 61.21 and 59.23%; cellulose, 46.56 and 41.51%; and dry matter intake, 6.29 and 6.62 kg./day. For the third trial, coastal Bermudagrass hay was compared with an excellent quality, early-cut alfalfa hay. The following results were obtained, respectively: digestible energy, 2061.6 and 2499.2 Cal./kg.; digestibility of dry matter, 52.55 and 61.56%; protein, 46.36 and 75.16%; cellulose, 54.32 and 62.06%; and dry matter intake, 4.58 and 4.49 kg./day.

EFFECT OF IMPLANTING DIFFERENT LEVELS OF STILBESTROL IN GRAZING BEEF STEERS. J. P. Fontenot, R. F. Kelley and J. A. Gaines, *Virginia Agricultural Experiment Station, Blacksburg.*

An experiment was conducted during two grazing seasons with fattening grazing steers (average initial weight, 955 lb.). Each year five lots of eight steers each were implanted in the ear at the beginning of the grazing season with the following levels of stilbestrol: Lot 1—none; Lot 2—12 mg.; Lot 3—24 mg.; Lot 4—36 mg.; Lot 5—48 mg. Average daily gain for Lots 1, 2, 3, 4 and 5 was 1.25, 1.50, 1.58, 1.52 and 1.50 lb., respectively. The gain increase from stilbestrol was highly significant. Increasing the level from 12 to 24 mg. did not significantly increase gain. The 12-mg. level did not affect carcass grade; increasing the level to 24 mg. tended to decrease it; and, increasing the level from 24 to 36 and 48 mg. significantly ($P<0.05$) depressed it. A small decrease in dressing percent, which approached significance at the 5% level, resulted from stilbestrol. The average loin eye muscle area for Lots 1, 2, 3, 4 and 5 were 11.2, 12.3, 12.3, 12.2 and 12.8 sq. in., respectively. Carcass length was not affected appreciably. Stilbestrol produced a slight tailhead elevation and a marked increase in teat length and seminal vesicle weight.

SUBSEQUENT PERFORMANCE OF STILBESTROL-IMPLANTED CATTLE ON PASTURE AND IN THE FEED LOT. A. B. Nelson and L. S. Pope, *Oklahoma Agricultural Experiment Station, Stillwater.*

A total of 216 grade Hereford cattle have been used to evaluate the effect of stilbestrol implantation on subsequent performance. Implantation of suckling calves with 12 or 24 mg. of diethylstilbestrol has increased gains an average of 12%. When such calves were full-fed fattening rations in dry-lot in 1956–57 the feed-lot gains of both groups were essentially the same, 406 and 410 lb., for control and previously-implanted calves, respectively. In 1957–58, heifer calves whose summer gain had been increased 33 lb. by implants gained 31 lb. more in dry-lot than the control calves. One-half of the calves in the first test and all calves in the second test were fed stilbestrol during the fattening period. Implanted steer calves gained 22 lb. more during the summer but 8 lb. less during fattening. The previously implanted cattle had a higher dressing percentage and carcass grade. Suckling calves whose gain was increased 36 lb. by stilbestrol lost 14 lb. in a subsequent wintering trial, and control calves lost 28 lb. Implanting yearling steers with 36 mg. of stilbestrol increased summer gains 24 lb. In a short period between end of the summer test and beginning of the feed-lot phase, the previously implanted yearlings gained 8 lb. more than the control cattle. This net increase to date of 32 lb. was reduced to 18 lb. by the end of the fattening period. Weanling steer calves were implanted with 0, 12, or 24 mg. of stilbestrol in a wintering trial on native grass. Winter gains were 8, 20 and 32 lb., respectively. During the subsequent summer the gains were 258, 244 and 256 lb., respectively.

EFFECTS OF SELECTED PHYSICAL AND ECONOMIC VARIABLES ON PRICES OF CALVES IN VIRGINIA FEEDER CALF SALES. Kenneth C. Williamson, R. C. Carter, G. W. Litton, J. D. Johnson and J. A. Gaines, *Virginia Polytechnic Institute, Blacksburg.*

Records of 21 Virginia feeder calf sales held annually from 1951 through 1956 were studied to determine the effect of size of sale, size of sale lot, weight, grade and breed on the average prices received for calves. Effects were estimated by the least squares method. Prices for steer and heifer calves were analyzed. Prices of steer calves increased consistently and significantly as size of sale increased. The average difference in price amounted to 36 cents per hundredweight for each increase of 200 head. Size of sale did not have a statistically significant effect on the average price of heifers. A definite

price advantage was shown for selling steer calves in larger lots. Angus steers averaged 16 cents per hundredweight above, and Shorthorns $1.05 below, Herefords. Angus heifers averaged 39 cents above, and Shorthorns 16 cents below, Herefords. Straightbred calves averaged higher than crossbreds. These differences were $2.30 and $1.77 per hundredweight for steers and heifers, respectively. Steer calves weighing from 401 to 500 lb. sold significantly higher than those heavier or lighter. The same trend was indicated for heifers. "Fancy and choice" steer calves averaged $2.11 per hundredweight higher, and "medium" steers $2.45 lower, than those grading "good." The respective differences for "fancy and choice" and "medium" heifers were $1.45 above and $1.44 below the "good" grade.

METHODS OF MANAGEMENT FOR THE SMALL COMMERCIAL COW-CALF HERD UNDER A FALL CALVING PROGRAM. L. S. Pope, D. F. Stephens and Lowell E. Walters, *Oklahoma Agricultural Experiment Station, Stillwater.*

In three trials, 20 grade Hereford cows with calves in each of three lots were wintered on (Lot 1) native bluestem grass plus 2.5 lb. C.S. meal and 3 lb. ground ear corn per head daily, (Lot 2) sorghum silage from a self-feeding silo plus 1.5 lb. C.S. meal, and (Lot 3) rye- and vetch pasture (1.5 acres per cow) with oat hay and alfalfa as reserve feed supply. All cows grazed together during the summer. Calves were dropped in October-November, creep-fed and sold for slaughter in mid-June at approximately 8 months of age. Cows on rye-vetch pasture lost less weight during the winter than cows on silage or dry weathered grass plus supplement. There was no significant difference in percent calf crop weaned or cow weights at the end of the summer period. Calves from cows of lot 3 gained slightly less, consumed less creep feed and graded lower at slaughter; calves from cows of lot 2 tended to be slightly fatter than calves from other lots. Costs of maintaining a cow-calf unit was highest for Lot 2, and lowest for Lot 3. Oat hay and alfalfa was fed one winter when rye-vetch pasture was not available and proved equal to the native grass plus supplement or silage treatments. Considering all treatments, calves tended to grade average to high Good and yielded 55.5 to 56.4%; heifers were approximately ⅓ carcass grade above steers. An analysis of slaughter vs. feeder prices revealed that the calves would have sold most profitably as "two-way" calves-steers to feeders and heifers for slaughter. Adding 5 mg. stilbestrol per calf daily to the creep ration increased gains in three trials; adding 40 mg. antibiotic increased gains in two trials.

CONCURRENT CLINICAL AND RADIOISOTOPE INVESTIGATIONS OF ANAPLASMOSIS ANEMIA. Lon E. Foote and Sam L. Hansard, *Louisiana State University, Baton Rouge.*

Basic investigations were made of the physiological changes in 40 calves induced with Anaplasmosis. Ultra thin sections of the Anaplasma bodies characteristically located in the periphery of the erythrocyte were studied with the electron microscope. Total blood, red cells and plasma volume, total hemoglobin, red cell life span, plasma iron clearance and percentage red blood cells containing marginal bodies were determined before, during and following the onset of the disease. The results indicate: (1) The marginal body to be a clear space at the margin of the erythrocyte containing one to seven masses of dense particulate matter, 0.2 to 0.7 μ in diameter and variable numbers of strands, without presence of organelles of a true cell; (2) a marked and progressive decrease in total RBC volume and hemoglobin from 5 days before, until 2 to 3 days following peak Anaplasma marginal body counts; (3) a decrease in red cell life span, but increased radioiron carrying capacity during the recovery period; (4) during this period the disease appeared to have more effect upon the production of erythrocytes than upon hemoglobin formation, resulting in hyperchromic red cells with decreased longevity.

COMPARATIVE FEEDING VALUE OF DIFFERENT SILAGES WITH LIMITED CONCENTRATES FOR FINISHING BEEF HEIFER CALVES. C. S. Hobbs, O. Glen Hall and Hugh Felts, *University of Tennessee, Knoxville.*

Corn, Atlas sorghum, small grain, and orchardgrass-ladino clover silages have been compared for fattening beef heifer calves weighing approximately 400–500 lb. In two experiments with duplicate lots, the average daily gains (lb.) per heifer were: Corn silage, 1.65; sorghum silage, 1.64; small grain, 1.28; and orchardgrass-ladino clover, 1.74. For the small grain silage, oats-vetch was used the first year and a new variety of rye (Tetra Petkus) and vetch the second year. Heifer calves fed rye-vetch silage gained at a significantly ($P<.01$) slower rate than calves fed other silages in the second test. The average returns above feed costs per calf for the two years were: Corn silage-fed heifers, $39.54; sorghum silage-fed heifers, $39.42; small grain silage-fed heifers, $26.06; and orchardgrass-ladino clover-fed heifers, $39.83. Chemical analyses were made on representative samples of all silages. These results indicate that corn silage, sorghum silage, and orchardgrass-ladino clover silage with limited amount of concentrates make very economical finishing rations for beef heifer calves.

BREED AND SIRE DIFFERENCES IN GESTATION LENGTH OF BEEF CATTLE. John W. Thornton and J. N. Wiltbank, *Virginia Polytechnic Institute, Blacksburg.*

Data from the 1958 calf crop at the Beef Cattle Research Station, Front Royal, Virginia, were analyzed to determine the effect of breed and sire of calf on length of gestation. Breeding dates were determined by painting the bull's brisket and checking herds three times daily. All cows were palpated rectally at 60, 110 and 250 days after beginning of the breeding season to verify conception dates of repeat breeders. These data include 292 gestations; 105 Angus, 97 Hereford, and 90 Shorthorn. Calves dead at birth or doubtful breeding dates were not included. Average length of gestation was 279.5 days for Angus, 283 for Shorthorns, and 287.2 for Herefords, with a pooled within breed standard deviation of 7.6 days. Differences in gestation length of calves by different sires in the Angus breed were highly significant ($P<.001$). Sire differences were not significant in Herefords or Shorthorns. This study indicates that the genotype of the calf may be important in determining gestation length.

ECONOMY AND RATE OF GAIN AND QUALITY OF MEAT PRODUCED BY STEERS FATTENED IN DRY LOT AND ON WINTER FORAGE. PART I. FEEDING DATA. E. G. Godbey and R. F. Wheeler, *Clemson Agricultural College, Clemson, South Carolina.*

A three-year test has been completed in which steers averaging about 675 lb. were fattened in dry lot, on winter forage alone and on winter forage with supplemental feeding. Each year five steers were fed individually in dry lot and five were kept on rye grass and crimson clover pasture without additional feed. Twenty-five of the steers on pasture were put in the barn each morning and fed individually; they were returned to pasture after eating as much grain feed as they desired. The ration fed in dry lot was a ground mixture of yellow corn, oats and cottonseed meal. Cottonseed hulls were the roughage. The forage steers were fed one of the following ground grains: (1) shelled yellow corn, (2) milo, (3) barley, (4) oats, (5) same grain mixture as used in the dry lot. The daily gains varied from 2.60 lb. for those fed in dry lot to 2.23 lb. for those on forage without feed. The kind of grain fed to the steers on forage did not have marked influence on the daily gains. The feed cost per 100 lb. of gain varied from $7.08 for those on forage without feed to $19.44 for those in dry lot. These costs were significantly different from those of lots fed on forage, which averaged $11.93. The profit per steer was largest ($46.02) for the cattle on forage alone and least

($12.91) for those fed in dry lot. The profits were approximately the same when the steers were fed corn, milo or barley on forage. When oats were fed the profit per head was not significantly different from that made by the cattle on forage alone.

ECONOMY AND RATE OF GAIN AND QUALITY OF MEAT PRODUCED BY STEERS FATTENED IN DRY LOT AND ON WINTER FORAGE. II CARCASS DATA. E. G. Godbey, D. H. Kropf and R. F. Wheeler, *Clemson Agricultural College, Clemson, South Carolina.*

Purebred and grade Hereford and Angus steers were fed as follows: Lot 1 (dry lot) equal parts of ground yellow corn, ground oats and cottonseed meal with cottonseed hulls full-fed as roughage; Lot 2 ground yellow corn; Lot 3, ground milo; Lot 4, ground barley; Lot 5, ground oats; Lot 6, equal parts ground yellow corn, ground oats and cottonseed meal full-fed and Lot 7, forage alone. Lots 2 through 7 were carried on forage of crimson clover and rye grass. Five steers were started in each lot in each of 3 years. Individual steers were removed from test when they reached a live slaughter grade of U. S. Good. They were slaughtered in a commercial packing plant. Carcass grade, dressing percentage, percent separable fat, lean or bone in the 9–10–11 rib sample, moisture and ether extract of the 9–10–11 rib sample, rib eye area and ether extract or moisture content of the L. dorsi sample (removed at 12th rib) were not significantly affected by treatment. Specific gravity of the 9–10–11 rib sample was lowest in Lot 1 carcasses and highest in Lots 3 and 7. The Iodine Number of fat was lowest ($P=.01$) from Lot 1 and highest from Lot 7 (forage alone).

CARCASS STUDIES WITH STEERS, BULLS AND STILBESTROL-IMPLANTED BULLS SOLD AS SLAUGHTER CALVES. D. H. Pilkington, L. E. Walters and L. S. Pope, *Oklahoma Agricultural Experiment Station, Stillwater*

Fall-dropped Hereford steer and bull calves were used to study the effect of castration and stilbestrol on gains and carcass composition at approximately 8 months of age. The calves were allotted to three groups of 10 calves each according to age, weight, sire and production records of their dams. Lot 1 was castrated while Lots 2 and 3 were left as bulls. Lot 3 bull calves were implanted with 12 mg. of stilbestrol at 3½ months of age and again at 6½ months with 24 mg. All calves and their dams were on wheat pastures until April, and on native grass until the close of the experiment. All calves were creep-fed throughout the experiment and sold for slaughter June 23. Carcasses were graded acording to U.S.D.A. specifications. Wholesale ribs were used to study the percent lean, fat, and bone, and for organoleptic tests. Average daily gains, 2.06, 2.19 and 2.12 for steers, bulls and implanted bulls, respectively, were not significantly different. Carcasses from Lot 2 bulls had significantly larger rib eye area, followed by implanted bulls and steers. The same relationship held true for the percent lean as estimated by the physical separation of the 9–10–11 rib cut. There was no significant difference between lots for percent bone or for tenderness of broiled steaks as determined by the Warner-Bratzler Shear.

RELATIONSHIPS OF CERTAIN MUSCLE AND BONE CHARACTERISTICS IN BEEF CARCASSES. D. H. Kropf, *Clemson Agricultural College, Clemson, South Carolina.*

Certain carcass measurements were obtained from 29 beef carcasses ranging in grade from High Standard to High Good and ranging from 412 to 582 lb. in hot carcass weight. Non-significant correlation coefficients of +0.14, +0.17 and +0.21 were found respectively between length of vertebrae at the 1st rib, 7th rib and last rib and loin eye area. Percent lean in the 9–10–11 rib sample was correlated to carcass grade

(−.41*) and percent separable fat (−.89**). Loin eye area per 100 lb. carcass weight was most strongly related to percent separable lean (r=+0.41*), length of the ulna (r=−.37*), and large circumference of the ulna (r=−.45*). No other significant correlation coefficients were found between either percent separable lean of the 9–10–11 rib sample or loin eye area per 100 lb. carcass weight and carcass grade, dressing percentage, percent fat or bone in rib sample, percent radius or ulna of carcass weight; specific gravity, length, circumference, or length to circumference ratio of the radius or the ulna. Specific gravity of the 9–10–11 rib sample showed the strongest relationship to percent bone (r=+0.82**) and percent fat (r=−.73**) and lesser relationships to percent separable lean (r=0.45*) and loin eye area per 100 lb. carcass weight (r=+0.23).

CORRELATION OF RIBEYE SIZE AND SEPARABLE LEAN OF VARIOUS BEEF CUTS TO TOTAL SEPARABLE LEAN OF THE CARCASS. J. W. Cole, L. E. Orme and C. M. Kincaid, *University of Tennessee, Knoxville.*

Area and the "shape index" of the *Longissimus dorsi* have been used as an index to the total muscling of a carcass. This study was undertaken to determine the usefulness of the ribeye area or a particular beef cut to predict total carcass lean. Fifty steers, nine heifers and nine cows representing the British, Brahman, large and small dairy breeds and various crosses of the above breeds, and representing the following U.S.D.A. grades of beef; choice (13), good (18), standard (27), commercial (9), and utility (4) were used. The lean, bone and fat were physically separated, and measurements which included the area of ribeye were taken on one side of each carcass. A correlation coefficient of 0.454 was obtained between the area of the ribeye and total carcass lean. The area of ribeye was further correlated to the amount of lean in such wholesale cuts as the round (.409), sirloin (.207), shortloin (.526), rib (.452), and to the lean in such cuts as the 9–10–11th rib (.547), and the 6–7–8th rib (.295). Although all relationships were highly significant, except the sirloin and 6–7–8th rib cut, they accounted for only 17 to 28% of the variation in separable lean. On the other hand correlation coefficients of 0.956, 0.805, 0.845, 0.838, 0.935, 0.823 and 0.757 were obtained between total separable lean and the lean from the round, sirloin, shortloin, rib, chuck, 9–10–11 rib cut and the 6–7–8 rib cut, respectively. Therefore the lean content of any of the above-mentioned cuts would give a higher estimate of total carcass lean than ribeye area, since they were associated with 57–91% of the variation existing in total muscling.

EFFECT OF AUREOMYCIN, LOW LEVEL PHENOTHIAZINE AND DRY-LOT VERSUS PASTURE ON SUMMER LAMB GAINS. P. E. Loggins, M. Koger, A. C. Warnick and T. J. Cunha, *Florida Agricultural Experiment Station, Gainesville.*

In replicate 120-day summer feeding trials conducted during 1957 and 1958, 97 lambs of Hampshire, Rambouillet and Native breeding were allotted to four treatments: (1) Control ration of craked corn, ground snap corn, cottonseed meal and minerals; (2) control + phenothiazine and trace mineral salt mixture; (3) control + Aureomycin + phenothiazine and trace mineral mixture; (4) control + phenothiazine and trace mineral mixture. Groups 1, 2 and 3 were full-fed the concentrate mixture plus ad libitum alyce clover hay in dry-lot. Group 4 was full-fed the same concentrate mixture on pasture. Average daily gains for the 1957 trials were 0.22, 0.25, 0.23 and 0.13 per head, respectively, in the four groups. Average daily gains for the 1958 trials were 0.29, 0.28, 0.29 and 0.096 per head, respectively. The statistical analyses showed no significant difference between gains in groups 1, 2 and 3. The gains were highly significant ($P<.01$) between dry-lot and pasture. Slaughter grades were lower ($P<.01$)

on pasture fed lambs. Mortality was high in Hampshire and Rambouillet lambs on pasture in 1957. Five of seven Hampshire, five of ten Rambouillet, and only one of five Native lambs were lost. In dry-lot only one of 28 lambs was lost. In 1958 there was available only one Hampshire and one Rambouillet lamb for the pasture group. The remaining ten lambs were Native or a Native-Rambouillet cross. The Hampshire lamb died on test and the Rambouillet died 16 days after end of trial. None of the Native or Native-Rambouillet cross lambs died on pasture. Three of the 35 lambs in dry-lot died of unknown causes.

EFFECTS OF OVARIAN HORMONES ON RATE OF GAIN AND GRADE OF LAMBS GRAZED ON WINTER PASTURES. Bryan Baker, R. A. Edgar and J. C. Dollahon, *Mississippi State University, State College.*

The practice of finishing lambs on winter pastures in Mississippi has become of increasing importance. In an attempt to produce faster and more economical gains, the effects of 3 and 6 mg. diethylstilbestrol implants were studied with ewe and wether lambs at five locations in Mississippi. Wether lambs at two of these locations received Synovex implants (2.5 mg. estradiol and 25 mg. progesterone). A total of 894 lambs were randomly assigned to the various treatments and grazed on winter pasture crops. Highly significant ($P=0.01$) differences in rates of gain existed between treatments, sexes, location and pastures. Adjustment of the ewe average daily gains to wether gains removed the highly significant sex difference, which indicated that the original difference between sexes was due to the difference in the gaining ability of ewes and wethers and that both sexes responded equally well to the hormone treatments. Groups implanted with 3 and 6 mg. diethylstilbestrol gained faster than the control groups ($P=0.01$). The difference between the gains made by the 3 and 6 mg. groups was not significant.

EFFECT OF ENVIRONMENTAL TEMPERATURE AND PROGESTERONE—PMS TREATMENT ON THE REPRODUCTIVE PERFORMANCE OF EWES. C. O. Woody, Bryan Baker, Jr., and C. W. Alliston, *Mississippi State University, State College.*

In 1957 and 1958 ewes were alloted to four treatments; air-conditioned (a/c) at 65°, treated; a/c, non-treated; * outside, treated and outside, non-treated. The hormone treatment (14 daily 10-mg. injections of progesterone plus 20 C-N units of PMS on day 16) was designed to terminate anestrus. All ewes checked twice daily for estrus and bred to a/c rams twice during each estrus period. The number of ewes showing estrus within the first 18 days: a/c, treated—15/15 (1957) and 17/17 (1958); a/c, non-treated 7/14* (1957) and 6/17 (1958); outside, treated—15/15 (1957) and 15/17 (1958); and outside, non-treated—4/15 (1957) and 8/17 (1958). In the above order of groups and years the number of ewes lambing ** was: 13/15 and 17/17, 12/14 and 16/17, 8/15 and 13/17, and 12/15 and 13/17; the mean settling dates ** were: Aug. 4 and July 9, Aug. 4 and July 11, Aug. 5 and July 7, and Aug. 19 and July 12; the mean number of services per ewe were: 1.73 and 1.24, 1.25 and 1.29, 3.53 and 1.7, and 2.33 and 1.94. In 1958 there was a difference between the average rectal temperature of the a/c ewes, 101.9, and the outside ewes, 102.5, at first breeding ($P=0.01$). The correlation coefficient for rectal and ambient temperatures was 0.589 for 193 measurements ($P<0.01$). From the initial measurement to 18 days the average hematocrit reading of the treated group in 1958 decreased from 38.10 to 33.26; the non-treated ewes decreased from 37.60 to 36.69 ($P<0.01$).

* One died early; in the experiment in 1957.

** Since the 1958 ewes had not completed lambing at the time this abstract was written, the 1958 data are based on breeding records. A ram was kept with unsettled ewes for one month after termination of record keeping.

SOME FACTORS AFFECTING BREEDING PERFORMANCE AND EARLY LAMBING IN SHEEP. R. L. Wilson, W. C. Godley and Victor Hurst, *Clemson Agricultural College, Clemson, South Carolina.*

In 1956, 100 grade Rambouillet ewes were assigned to five lots of 20 each, to study the effects of light, temperature and hormones on breeding performance and early lamb production. Lot 1 was placed in a room where they received the number of daylight hours normal in the month of October. Lot 2 was placed in an air-conditioned room where the temperature simulated October's temperature. Lot 3 was placed in a room in which both October temperature and light conditions were simulated. Lot 4 received five injections of 30 mg. progesterone at 3-day intervals followed by 500 IU pregnant mare serum 3 days later. Lot 5 was the control. The breeding season extended from April 25 through June 15. In the first breeding season the ewes in all groups were bred to Suffolk rams kept under the same conditions as the ewes. In the last two breeding seasons the ewes were artificially bred with semen from Suffolk rams which were maintained under normal management conditions. For the three lambing seasons the average percentages of ewes lambing on each treatment were as follows: Lot 1—57; Lot 2—59; Lot 3—65; Lot 4—28; and Lot 5—34. It appears that control of light, or temperature, or both affected the percentage of ewes lambing. Lambing dates were not affected by the different treatments.

EFFECTIVENESS OF SELECTION FOR EARLY LAMBING. J. C. Dollahon and J. A. McGuire, *Mississippi State University, State College.*

Two closed lines of sheep were used to study the effectiveness of selection for earliness of lambing. The ewes and rams of the A-line were selected on the basis of age at puberty and earliness of lambing, whereas the B-line sheep were selected on conformation. The initial average date of lambing for the A-line ewes was February 8, as compared to March 3 for the B-line. The average lambing date 6 years later was December 25 for the A-line and January 24 for the B-line. Yearling ewes required an average of 2.16 services per conception in the A-line and 3.18 in the B-line. Ewes 6 years of age required 1.42 services per conception in the A-line as compared to 2.50 in the B-line. The average date of first estrus after June 15 was August 14 for the A-line yearling ewes and August 6 for the B-line ewes. When the ewes reached 6 years of age these dates had changed to July 15 for the A-line and August 1 for the B-line. Heritability estimates computed from the compiled data are 0.60 and 0.80 for date of lambing, 0.33 for average daily gain, 0.17 for number of services per conception, 0.70 for weaning grade and 0.61 for birth weight. All estimates were made by the intra-sire regression of daughter on dam method except the 0.80 for date of lambing, 0.35 for average daily gain and 0.70 for weaning grade which were computed by the paternal half-sib method.

SUMMER SEMEN CHARACTERISTICS OF RAMS HAVING FREE ACCESS TO A PLASTIC AIR-CONDITIONED ROOM. E. C. Simpson, H. C. Rice, D. G. Steele, R. H. Dutt, *University of Kentucky, Lexington.*

Eight crossbred rams (Southdown X western crossbred ewes) were randomly divided into treated and control groups on June 15. The treated group was kept in a lot where they had free access to a room 10′ x 10′ x 6′ constructed of two layers of plastic utilizing a dead-air space for insulation, and containing a ¾-ton home air-conditioning unit. The room which was located in an open metal barn had a 15° F. temperature differential on hot days. Control rams were kept in a similar area but without access to the air-conditioned room. Laboratory studies were made on weekly semen collections. Volume of semen, percent motile cells, sperm-cell concentration and percent abnormal cells for the treated and control groups were: 0.79 and 0.67 ml.; 84 and 67%; 2.1 and 1.6 billion per ml.; and 8.7 and 19.4%, respectively. There was either a signif-

icant or highly significant difference in the semen characteristics. Effects of the cool room was most pronounced on percent abnormal cells. Rectal temperature of the treated rams at 2 p.m. on days when the temperature was 90° F. or higher averaged 1.6° F. lower than that of the control rams.

PREFERENCE FOR FEED PREPARATIONS BY SHEEP. C. J. Brown and Jack W. Caveness, *University of Arkansas, Fayetteville.*

Eleven grade Rambouillett ewes were allotted to separate pens in a room which permitted observation of behavior at feeding time. Corn, oats, milo and wheat were compared when fed as whole grain, finely ground, crimped and pelleted. One-half lb. of all grains being tried was offered to each ewe for a 30-minute feeding period each day and all grains were offered initially in each series of observations. Each feed was placed in the pen in a different position determined at random at each feeding. The grain that was eaten first most frequently was removed after observations for 2 days. The three least preferred grains were then offered for a 2-day period and the grain preferred first most frequently was removed. The remaining two least preferred grains were offered for 2 days. Observations of first choices, number of times and amounts eaten were studied as measures of preference for grains and preparations. Differences were not significant for frequency that grains or preparations were preferred first or in total number of times that grains or preparations were eaten. Preparation differences were significant but grain differences were not significant for proportion of grain consumed. The ewes consumed 60% of the whole grain whereas they consumed 94%, 90% and 88% respectively of finely ground, crimped and pelleted preparations. It was possible to alter choice of the first grain preferred through blindfolding or through inhibiting the sense of smell.

BIOLOGICAL EVALUATION OF DRACKETT PROTEIN WITH MATURE WETHERS. J. W. Stroud, J. S. Mobberly, F. H. Baker, and R. B. Grainger, *University of Kentucky, Lexington.*

A metabolism trial with 24 mature wethers was conducted to evaluate the nitrogen of Drackett protein. This product was fed at levels of 0.00%, 4.02%, 8.04%, 12.05% and 16.07% in rations containing 50% cottonseed hulls. Nitrogen in cottonseed hulls was considered unavailable. Individual daily fecal and urinary excretions of each wether were analyzed for nitrogen. Fecal metabolic protein determined directly by feeding a ration devoid of available protein was 2.56 ± 0.34 gm. per 100 gm. of dry matter intake or 4.50 ± 0.57 gm. per 100 gm. of dry matter excreted. A value determined indirectly, by extrapolating the regression line of fecal protein on protein intake, was 2.79 ± 0.27 gm. of protein per 100 gm. of dry matter intake. Endogenous urinary nitrogen determined directly was 28.3 mg. per kg. of body weight. The biological values of Drackett protein fed at levels of 4.02%, 8.04%, 12.05% and 16.07% were 79.51%, 62.93%, 57.19% and 44.10%, respectively. Mature wethers fed this ration required between 4% and 8% Drackett protein for maintenance. An eight-day preliminary period reduced protein excretions to the metabolic and endogenous levels. Either method of fecal metabolic protein determination was satisfactory. Protein deficiency decreased dry matter digestibility significantly.

PASTURE AND DRYLOT FATTENING OF WESTERN FEEDER LAMBS WITH AND WITHOUT TRANQUILIZER. P. G. Woolfolk, L. H. Boyd, B. J. Greiman and T. J. Davidson, *University of Kentucky, Lexington.*

Various systems of fattening western feeder lambs were studied in a trial with 279 North Dakota wethers. The lambs were received in mid-October and maintained on

bluegrass pasture until put on feed Dec. 10, 1957. Hydrozyzine was fed either mixed with soybean oil meal or salt in the case of the wheat pasture lot at the rate of 2.5 mg. daily per lamb. Lots through 5 were fed completely in drylot; lots 6 and 7 were allowed to graze bluegrass pasture during the day; lots 8, 9, and 10 were run entirely on pasture, with no shelter available, but fed a small amount of alfalfa hay during snowy weather in early February. The total alfalfa consumed averaged approximately 8 lb. per lamb for this period. Results show that gain and carcass quality equal to that obtained on excellent drylot rations can be obtained on wheat pasture alone with considerable saving of feed. Bluegrass pasture alone did not produce desirable gains or carcass quality. Bluegrass pasture in combination with drylot feeding did not result in a saving of feed. The bluegrass pasture, particularly for lots 6 and 7, was not of the best quality. The tranquilizer was of no benefit when the animals were either on pasture or in drylot.

EFFECTS OF DOCKING AND CASTRATION ON GROWTH AND QUALITY OF SPRING LAMBS. F. S. McClaugherty, R. C. Carter, and J. A. Gaines, *Virginia Agricultural Experiment Station, Blacksburg.*

The experiment was conducted at the Southwest Virginia Research Station at Glade Spring in 1958. Alternate ram lambs were docked and/or castrated and alternate ewe lambs docked at 1 to 2 weeks of age. The lambs were slaughtered at weights of 85 lb. or above in three drafts, May 6, May 26, and June 23. All were graded before slaughter by official state graders. Differences among the sexes in growth rate were highly significant ($P<.01$); rams averaged 0.556 lb. per day from tagging to marketing, ewes 0.535 and wethers 0.543 lb. Sex differences in slaughter grades were significant, ($P<.05$); rams averaged 14.2 (Choice +), ewes 14.9 and wethers 14.7 (both Prime −). Docking did not significantly affect growth rate or slaughter grade. In dressing percentage rams averaged 48.8, ewes 50.8, and wethers 50.0; docked lambs averaged 50.2 and those with tails 49.7. Differences in dressing percentage were not significant. A significant sex by date of marketing interaction was found in growth rate. Early ram lambs grew more rapidly, but late rams more slowly than ewes and wethers.

RESPONSE OF THE UARK POLAND CHINAS TO VARYING CALORIE-PROTEIN RATIOS. P. R. Noland, W. K. Scott, and C. A. Baugus, *University of Arkansas, Fayetteville.*

A litter of 60% inbred Poland China pigs was individually fed in a 9 x 9 Latin square experiment to evaluate rations containing varying quantities of protein and energy. Each ration was fed for a one-week period. Three energy levels were used, 950, 1050, and 1200 Calories of productive energy per lb., and three protein levels, 12, 16, and 20%, were fed at each level of energy. The ratios were composed of corn, soybean meal, minerals and vitamins. Ground rice hulls and stabilized animal fat were used to obtain the desired energy levels. Analysis of variance of gains indicated that the linear protein component was significant ($P=.01$), the 20% protein rations giving the fastest gains. The 1200-Calorie rations produced significantly faster ($P=.05$) gains than the 1050-rations. There was no statistically significant difference between the 950- and 1050-rations. Boars gained significantly faster than gilts ($P=.05$). The effect of period was significant ($P=.05$). Feed efficiencies indicated a significant protein effect ($P=.05$), both the linear and quadratic components approaching significance. Period effect on feed efficiency was significant ($P=.05$). Daily gains and feed efficiencies of the 950-, 1050-, and 1200-Calorie rations were 1.34, 3.75; 1.47, 3.27; and 1.75, 2.83 lb. respectively. Average daily gains and feed efficiencies of the 12, 16, and 20% rations were 1.31, 3.87; 1.61, 2.85; and 1.64, 3.13 lb., respectively.

EFFECTS OF CHANGING LEVELS OF NUTRITION ON REPRODUCTION OF GILTS. Bryan Baker, Jr., *Mississippi State University, State College.*

A study was made of the effects of changing levels of energy intake prior to and at the time of breeding on reproductive performance. Thirty-six gilts weighing approximately 100 lb. were randomly allotted to two lots. One lot was self-fed a 16% corn-soybean oil meal ration while the other was self-fed a 16% oat-soybean oil meal ration. The gilts were checked daily for estrus. On day 10 of the second observed estrual cycle two-thirds of the gilts in each lot were switched to the other ration and at breeding time one-half of the gilts so switched were returned to the original ration. All gilts were double-mated during the third estrus period and slaughtered 30–40 days later. The reproductive tracts were examined in detail. The gilts fed the oat ration reached puberty 13 days earlier on the average than the corn-fed gilts ($P<0.05$). The gilts that were switched from the oat ration to the corn ration prior to breeding had a significantly ($P<0.05$) higher ovulation rate than the other gilts. Gilts that were switched from the oat to the corn ration had a seemingly larger number of live embryos 30–40 days after breeding than the other groups, but differences were not significant.

SUPPLEMENT TO PEANUT OIL MEAL FOR GROWING-FATTENING SWINE. C. C. Brooks and H. R. Thomas, *Virginia Polytechnic Institute, Blacksburg.*

Two trials were conducted to determine whether supplements of lysine, lysine and methionine, either in pure form or from natural sources; namely, blood meal and fish meal, would make peanut meal a satisfactory source of protein for supplementing corn for growing pigs. In the first trial, the following supplements were added to corn-peanut meal rations for young pigs: L-lysine HCL 0.5%, lysine 0.5% and methionine 0.3%, blood meal 3%, and fish meal 5%. A corn-soybean meal ration was used as a positive control. In the second trial, the lysine was reduced to 0.3% and 0.2%. Each of these additives resulted in highly significant increases in rate of gain over lots receiving peanut meal-corn alone except when lysine was added by itself in the first trial. When lysine was fed at the high level, pigs made rapid early gains but growth rate was depressed as they grew older. At the lower level this depression did not occur. The supplemented rations produced gains equal to those made by pigs on corn-soybean oil meal rations. In both trials carcasses from pigs fed the supplements had significantly larger loin eye areas than pigs fed corn-peanut oil meal rations. Pigs fed the ration supplemented with lysine alone had the largest loin areas, differences being significant only in the first trial.

TALLOW FEEDING AT WEIGHT INTERVALS, STILBESTROL IMPLANTATION AND TRANQUILIZER FOR GROWING-FATTENING SWINE. D. M. Baird, H. C. McCampbell and W. E. Neville, Jr., *Georgia Experiment Station, Experiment.*

Purebred Poland Chinas were allotted into six drylot and two pasture lots and fed from approximately 47 lb. to 205 lb. Fat-fed lots received 8% prime tallow. A 3-mg. initial stilbestrol implant was used and tranquilizer (hydroxyzine) was fed at a level of 0.25 mg. per lb. of ration. Protein levels were 17, 15, and 13% for the drylot and 15, 13 and 11% for the pasture pigs with adjustments being made at 75, and 130 lb. liveweight. Treatments, A.D.G. and feed efficiencies were as follows: (1) control, 1.58, 354; (2) fat to 130 lb., 1.62, 324; (3) fat 130–205 lb., 1.67, 326; (4) fat 47–205 lb., 1.73, 308; (5) control + stilbestrol, 1.83, 345, (6) 5 + tranquilizer 1.76, 317 lb. Pasture-fed animals gained 1.52 and 1.65 lb. daily with feed efficiency of 358 and 295 lb. for rations without and with added fat, respectively. For A.D.G., the only sources of variation found to be significant was sex (barrows > females, $P<.01$) and sex X treatment interactions (females > barrows in the stilbestrol lots, $P<.05$). Treatments

had no significant effect on the observed carcass characteristics. There was a highly significant treatment X sex interaction for dressing percent, backfat, hardness grade and marbling. Sex X treatment interaction was significant for carcass length and lean color of the loin eye muscle. Sex source of variation for cooler shrink was significantly different (males > females, $P<.05$). Fat tended to depress feed consumption. Tranquilizer (1.4 mg. daily) produced no noticeable sedation. Vulva hyperemia was the only apparent side effect due to stilbestrol.

VALUE OF HYGROMYCIN B AS AN ANTIBIOTIC AND AS AN ANTHELMINTIC FOR SWINE. S. A. Griffin and C. C. Chamberlain, *University of Tennessee, Knoxville.*

Forty-eight Hampshire and Duroc pigs were assigned to 12 lots of four pigs each and fed in concrete pens from a weight of 50 lb. to a weight of 200 lb. Six treatments were used with two replicates per treatment. All pigs were fed corn and supplement free choice. The treatments were: I, Basal; II, Basal + 72 gm. Aureomycin per ton of supplement; III, Basal + 24,000,000 units of hygromycin B per ton of supplement; and, IV, V, and VI the same, respectively. Pigs on treatments I, II, and III only were wormed (sodium flouride) prior to the experiment. The daily gain and feed per 100 lb. of gain were: I, 1.76—388; II, 1.79—397; III, 1.75—407; IV, 1.82—409; V, 1.77—392; VI, 1.67—403. There were no significant differences in rate of gain or feed per 100 lb. of gain. There was considerable feed wastage in all lots. Two pigs from each lot were examined for round worms at slaughter. The average number of ascarids recovered per pig on the various treatments were: I, 3.75; II, 1.50; III, 0; IV, 12.25; V, 10.75; VI, 0.25.

EFFECTS OF HYGROMYCIN B IN PREVENTING INTERNAL PARASITE INFESTATION AND CARCASS DAMAGE IN GROWING SWINE. R. F. Sewell, R. W. Shackelford and J. L. Carmon, *University of Georgia, Athens.*

Two groups of 32 pigs each were used in this study. One group received hygromycin B in the feed continuously from the time they started to consume a pre-starter ration until reaching market weights. The other group served as control. All pigs were fed on parasitized pasture areas. There was slight improvement in rate of gain and feed efficiency for the group receiving hygromycin. Fecal egg counts obtained periodically revealed a decrease in the average number of ascarid eggs per gram of feces from 435 for the controls to 2.23 for the pigs receiving hygromycin. All pigs were followed through terminal studies in which the intestinal tract of each pig was examined. No ascarids were found in the pigs receiving hygromycin whereas an average of 2.14 were found in the control group. There was no difference in the number of livers condemned for human consumption between the two groups when examined under federal inspection.

UTILIZATION OF HIGH-FIBER RATIONS FOR BREEDING SWINE. K. W. Scott and P. R. Noland, *University of Arkansas, Fayetteville.*

The utilization of high fiber rations for limiting the energy intake of bred swine was studied to ascertain its effects on growth rate and pig production. In this study 24 bred females were stratified and allotted to three pens of eight animals each. All were self-fed for 116 days on the following rations: Lot 1—15% protein Basal ration; Lot 2—an 80:20 mixture of Basal: ground rice hulls; Lot 3—a 60:40 Basal:rice hulls. Average daily gains and feed efficiencies were: Lot 1—2.38 and 549; Lot 2—1.76 and 796; Lot 3—1.99 and 805. Digestion trials were conducted on four animals from each lot. Digestibilities of fat, protein, and crude fiber were: Lot 1—83.0, 78.5 and 40.9; Lot

2—63.2, 74.8 and 15.8; Lot 3—74.3, 71.4 and 3.7. Thus, while fat digestion was variable, both protein and crude fiber digestion declined with increased amounts of rice hulls.

PERFORMANCE OF PIGS FATTENED IN CONCRETE DRY LOT AS COMPARED TO THAT OF PIGS FATTENED IN PASTURE PLOTS. O. M. Hale, W. C. McCormick and B. L. Southwell, *University of Georgia, Athens.*

A total of 520 feeder pigs, averaging approximately 63 lb. in weight, were used in the three trials of this study. One-half were fattened in the concrete dry lots and the other half in the pasture plots; all were fed the same ration. The pigs on pasture made average daily gains of 1.82 lb. as compared to 1.71 lb. for those on concrete. Pigs on pasture required 361 lb. feed per cwt. gain while those on concrete required 364 lb. Data obtained on 72 pigs, weighing between 200 and 230 lb., selected randomly from each treatment, showed no significant difference in carcass quality. The average length, backfat thickness and area of loin eye muscle of pigs fattened in pasture plots were 29.84 in., 1.74 in. and 3.87 sq. in., respectively, and 30.13 in., 1.79 in. and 3.97 sq. in., respectively, for those fattened in concrete dry lot.

PROTEIN SUPPLEMENT FOR GROWING-FINISHING PIGS IN DRY LOT AND ON ALFALFA PASTURE. C. E. Barnhart and J. R. Overfield, *University of Kentucky, Lexington.*

Three different supplements and a complete mixed feed were fed growing-finishing pigs grazing alfalfa pasture during the summers of 1956, '57 and '58 and pigs on concrete during the winters of 1956–57 and 1957–58. The supplements, self-fed free choice with shelled yellow corn, were: (1) a complete mixed supplement, (2) a supplement composed of 50–50 meat scraps and soybean meal plus antibiotic, (3) a mixture of 80% soybean meal and 10% limestone plus an antibiotic (this supplement was fed during the summer but was altered to include vitamins and minerals for the dry lot tests). The fourth treatment was a complete mixed ration including ground yellow corn and a supplement similar to number 1. The protein level of the complete ration was adjusted to conform with the needs of the pigs as they became heavier. Two replicate lots of five pigs each were fed each treatment each year. Average daily gains in lb. and lb. of feed consumed per 100 lb. of gain for ration treatments 1, 2, 3 and 4, respectively, were: Pasture 1.48, 310.9, concrete 1.61, 337.1; pasture 1.55, 321.4, concrete 1.55, 358.1; pasture 1.32, 328.3, concrete 1.59, 348.6; and pasture 1.61, 325.3, concrete 1.82, 351.7.

PERFORMANCE OF STRAIGHTBRED AND CROSSBRED SWINE. H. J. Smith and R. P. Moorman, *University of Tennessee, Knoxville.*

The performance of 134 straightbred (Duroc, Hampshire, Poland and Landrace) and 115 crossbred (two-, three-, and four-breed crosses) litters farrowed in the spring and fall of 1956 and 1957 were studied to compare the productivity of straightbreds with various breed crosses. Performance characteristics studied were the number of pigs farrowed, number weaned, and number raised to 154 days; individual pig weights at birth, 56 days and 154 days; litter weights at birth, 56 days and 154 days; and backfat thickness at 200 lb. Analyses of differences between straightbreds and crossbreds were restricted to within season comparisons. Crossbred sows (two- and three-breed cross sows) farrowed larger litters and crossbred litters were significantly larger at 56 and 154 days. Crossbred pigs gained significantly faster from birth to market and were significantly heavier at weaning and 154 days as compared to straightbred pigs, reflecting the effects of greater pig survival and growth ability in crossbred litters. The backfat thickness of the straightbred Landrace pigs was significantly lower than other straightbreds and this breed was very effective in reducing backfat thickness in crosses.

EFFECTS OF A TEMPERATURE RISE DURING PORK CURING. M. C. Heck, *University of Arkansas, Fayetteville.*

Hams and shoulders from 15 pork carcasses were randomized into three dry-cure groups and two temperature groups. The cures were sugar, salt and Smithfield. Cuts in temperature group 1 were continuously cured at 38° F. (control). Cuts in temperature group 2 were cured at 38° F. for 2 weeks then at room temperature (56–60° F.) for 4 days and again at 38° F. for the remainder of the curing period. Organoleptic scores were given each ham and shoulder. Curing at room temperatures for 4 days did not significantly lower quality factors. Later one ham from each of 12 pork carcasses was randomly selected for continuous curing at 38° F. along with the opposite shoulder. The remaining ham and shoulder was cured at 38° F. for 3 weeks, then at room temperature (48–70° F.) for 1 week and again at 38° F. Weather conditions, internal ham and shoulder temperature and loss of weight during curing and smoking were recorded. Shear test and organoleptic panel scores were taken. Curing at room temperature for 1 week did not significantly change the weight loss during curing and smoking or lower the quality factors. The shear test mean difference between treatments was not significant. These data indicate hams and shoulders may be cured successfully for as long as 1 week at higher temperatures than 38° F. provided the meat has been chilled promptly, and cured at 38° F. before the rise in temperature.

ABSTRACTS OF PAPERS PRESENTED AT MEETING OF THE WESTERN SECTION, A.S.A.P., JULY 13, 14, 15, 1959, TUCSON, ARIZONA

SEASONAL CHANGES IN COAT CHARACTERS IN RELATION TO PERFORMANCE IN CATTLE.

G. I. Alexander and Ralph Bogart, *Oregon Agricultural Experiment Station, Corvallis.*

Forty-eight calves of both sexes from three lines of Herefords and one line of Angus born in 1958 were used to determine the relation of time of shedding of the winter hair coat to rate of gain from birth to shedding and gains during the month preceding shedding. After weaning, the calves were fed a pelleted ration composed of 2 parts chopped alfalfa to 1 part of concentrate. There were marked sex differences in rate of gain for both periods. However, no differences were found in growth from birth to time of shedding for animals which shed their hair coats early or late. Also, there was no sex×time of coat shedding interaction. This shows that there is no relationship between time of shedding and rate of gain of beef calves maintained on a uniformly high nutritional plane.

EFFECTS OF INBREEDING ON PERFORMANCE CHARACTERISTICS IN INBRED LINES OF BEEF CATTLE.

G. I. Alexander and Ralph Bogart, *Oregon Agricultural Experiment Station, Corvallis.*

Two hundred and eighty calves of both sexes from the three Hereford and one Angus inbred lines born in the years 1952–57 inclusive and maintained at this station were used to determine the effect of inbreeding in a series of least-squares models from which the effect of the mating system had not been removed. The performance characteristics considered were birth weight, suckling gain, age at 500 lb. body weight, rate of gain on feed test, feed consumption per unit gain and age at 800 lb. body weight. The inbreeding coefficients varied from 0 to 41%. Significant effects of years were found in every case and inbreeding exerted a significant influence on suckling gain, age at 500 lb. and age at 800 lb. body weight. However, there was no effect of inbreeding on birth weight, rate of gain and feed consumption per unit gain. No reason could be advanced for the lack of influence of inbreeding on birth weight but those of inbreeding on the feed test criteria were considered to be due to the compensation of selection for the expected inbreeding depression.

ENVIRONMENTAL FACTORS AFFECTING AND CORRELATIONS INVOLVING RATE AND EFFICIENCY OF GAIN AND OTHER POSTWEANING TRAITS OF RAMBOUILLET LAMBS.

K. R. Frederiksen, D. A. Price and S. K. Ercanbrack, *U. S. Sheep Experiment Station, Dubois, Idaho.*

A total of 144 randomly selected Rambouillet ram and ewe lambs averaging 270 days of age were fed individually on a pelleted growing ration for 84 days during the winters 1956–58. Least squares estimates of the effects of year of test, age on test, sex, age of dam, and type of birth and rearing on the following traits (shown with means and standard deviations) were obtained: initial body weight, 90 lb., 9.35; daily feed consumption, 4.98 lb., 0.60; daily gain, 0.56 lb., 0.09; lb. of feed per lb. gain, 9.16, 0.99; initial body type score, 2.96, 0.42; initial condition score, 3.00, 0.39; and initial staple length, 5.49 cm., 0.60. Age on test had a significant ($P \leq .01$) effect on body weight, lb. of feed per lb. gain, body type and condition scores, and staple length. Ram lambs were significantly heavier (15.1 lb.), consumed more feed per day (1.57 lb.), gained faster (0.27 lb.), and required less feed (1.69 lb.) per lb.

of gain than ewe lambs. Offspring from mature ewes were significantly heavier (6.1 lb.) than those from 2-year-old dams. Single lambs were significantly heavier (10.7 lb.) and consumed more feed per day (0.32 lb.) than twin lambs. Correlations among the traits, independent of the above effects, were calculated. Body weight was significantly ($P \leq 0.01$) correlated with daily feed consumption (0.59), lb. of feed per lb. gain (0.37), type score (—.52), condition score (—.45), and staple length (0.26); daily feed consumption with daily gain (0.77), type (—.29), and condition (—.26); daily gain with lb. of feed per lb. gain (—.63); body type with condition (0.53) and staple length (—.49); and condition with staple length (—.36).

GENETIC AND ENVIRONMENTAL FACTORS AFFECTING THE BIRTH COATS OF RAMBOUILLET, TARGHEE, AND COLUMBIA LAMBS. L. O. Wilson, S. K. Ercanbrack, D. A. Price and C. E. Terrill, *U. S. Sheep Experiment Station, Dubois, Idaho.*

Separate scores were obtained on the amount of hair and wool on the birth coats of 10,119 Rambouillet, Targhee, and Columbia lambs born at the U. S. Sheep Experiment Station from 1950 through 1953. Least squares estimates of the effects of sex, type of birth, age of dam, breeding group, birth weight, birth date, inbreeding, and year of observation on the two kinds of scores were obtained. The mathematical model accounted for about 4 and 19%, respectively, of the total variation in hair and wool covering. Results indicated that males had significantly ($P \leq .05$) less hair and wool at birth than females. Single Rambouillet and Columbia lambs had significantly more hair than twins, but type of birth did not significantly affect wool covering. Rambouillet and Columbia lambs from 2-year-old dams exhibited significantly less hair and wool than lambs from 3-year-old dams. Rambouillet lambs from 6-year-old dams showed significantly less hair and wool than lambs from 7-year-old dams. However, Targhee lambs from 6-year-old dams exhibited significantly more wool than lambs from 7-year-old dams. Differences associated with Rambouillet breeding groups were significant for both hair and wool, but comparable differences in the other breeds were not significant. Heavier lambs at birth had significantly greater wool covering than lighter lambs, but no significant differences were observed in hair covering. Birth date had some significant but unimportant effects. The more highly inbred Rambouillet lambs had significantly more hair covering. Inbreeding had a significant but unimportant effect on wool covering in Targhee and Rambouillet lambs. The effects of year of observation were significant in all breeds.

RELATIONSHIP BETWEEN LIVE LAMB MEASUREMENTS AND MEATINESS. M. P. Botkin, Marion Stanley and C. O. Schoonover, *University of Wyoming, Laramie.*

Live measurements and carcass measurements were taken on 141 lambs over a period of 3 years. When carcasses were cut, photographs were taken of the cross section of the loin eye and of the leg, and these lean area measurements used as a measure of meatiness. Measurements included here were live leg width, carcass leg width, live cannon bone circumference and length, actual cannon bone circumference and length, and actual cannon bone widths. These measurements were studied for their relationship to loin eye area, to leg area and to "total" area (leg area + 4 loin eye area). In all cases, leg area was more closely related to the measurements than was loin eye area, "total" area being intermediate. Also, leg area seems to be a better measure of meatiness than is loin eye area. Carcass leg width was highly correlated to leg area. Live leg width was not quite as highly correlated to leg area as was carcass leg width, but seems to be a good indicator of leg area if measurement

technique can be refined. Physical separation of 30 carcasses into lean, fat and bone, gives indication that area of loin eye and area of leg combined is reliable as a measure of lean meat content.

SKELETAL DEVELOPMENT IN RELATION TO MUSCLE DIFFERENTIAL DEVELOPMENT. E. S. E. Hafez, *State College of Washington, Pullman.*

Thirty-four gilts were fed on two planes of nutrition and slaughtered at a live weight of 200 to 300 lb. The *Longissimus dorsi* and Psoas major muscles were dissected and weighed; the surface area of the former cross section was measured. The lean, bone and fat of half the carcasses were dissected and weighed. The skull and the individual long bones were treated with NaOH, dried, measured and weighed. The weight of the femur or skull and the $\frac{\text{width}}{\text{length}}$ of femur or thickness of humerus were the skeletal measurements best related to muscling qualities. These values were positively correlated with weight of lean in high priced cuts and negatively correlated to lean:fat and lean:bone ratio of carcass. The thickness of cannon bone was correlated to weight of lean in loin and weight of Psoas major. The surface area of the cross section of *Longissimus dorsi* was positively correlated with weight of skull and mandible; $\frac{\text{femur length}}{\text{femur width}}$, thickness of femur and humerus. The $\frac{\text{weight of humerus}}{\text{lean of picnic}}$ was negatively correlated with loin surface area. The total weight of bones in ½ carcass was highly correlated with total lean, total subcutaneous fat and total inter-muscular fat.

CARCASS CHARACTERISTICS IN THE HOMOZYGOUS HEREFORD DWARF. E. S. E. Hafez, E. H. Rupnow, C. C. O'Mary and M. E. Ensminger, *State College of Washington, Pullman.*

Sixteen Hereford dwarfs and five controls 6 to 8 months old were slaughtered. Relative measurements and weights of primal cuts and organs were recorded for cooled carcasses. The rib eye muscle cross section was measured and the tenderness of roasts were tested by a taste panel. In dwarfs the live weight ranged from 174 to 348 lb. and the dressing varied from 54.27 to 59.01%. In the control, the live weight ranged from 331 to 470 lb. and the dressing varies from 59.67 to 63.53%; the dressing percentage was significantly higher in the controls than the dwarfs. The carcass conformation of the dwarf seems to be proportionate except with respect to the following ratio measurements; $\frac{\text{width of round}}{\text{width of body}}$, $\frac{\text{width of shoulder}}{\text{width of body}}$, and $\frac{\text{length of abdominal cavity}}{\text{length of thoracic cavity}}$. The last ratio was associated with a relatively large abdominal cavity of the dwarf, because of increased size of the digestive tract. The percentage weight of round, shank, head and vital organs was higher and the percentage weight of flank, rib, and of abdominal fat was higher in the dwarfs than in controls. The average surface area of *Longissimus dorsi* cross section was 3.66 in the dwarfs and 6.44 sq. in. in the controls. "Loin" roasts were less tender in dwarfs than in controls while "round" roasts had the same tenderness.

EFFECTS OF STILBESTROL AND TESTOSTERONE IMPLANTATION ON THE CHEMICAL COMPOSITION OF THE 9–10–11TH RIB AND LONGISSIMUS DORSI MUSCLE OF STEER CARCASSES. W. H. Kennick, D. C. England and A. L. Anglemier, *Oregon State College, Corvallis.*

The relationship between the fat, protein and water content of the 9–10–11th rib and the *Longissimus dorsi* and several ration and hormone treatments was studied.

The hormone treatments were administered as implants at the beginning of the feed period and at 90-day intervals as follows: (1) control, (2) stilbestrol, stilbestrol, stilbestrol, (3) stilbestrol, testosterone, stilbestrol, (4) no implant, testosterone, stilbestrol, (5) stilbestrol, no implant, stilbestrol, (6) no implant, stilbestrol, stilbestrol. The concentrate feeding was adjusted at 90-day intervals and fed as a per cent of live weight as follows: (1) 1%, 1%, 1%, (2) 0.5%, 1%, 1.5%, (3) 1.5%, 1.5%, 1.5%. There was no significant difference in the fat, protein or water content of the 9–10–11th rib due to either hormone treatment or feed level. The water content of the *Longissimus dorsi* of the testosterone treated groups (3 and 4) was significantly ($P<.05$) lower than stilbestrol treated groups (2 and 5). The two testosterone treated groups had a higher percentage of fat in the *Longissimus dorsi* (mean= 3.86%) than any of the other hormone groups (mean=3.48). This difference was not significant at the 5% level. There was no significant difference in protein content due to hormone treatment. The 1.5% ration (3) had a non-significantly higher fat content and lower protein content with a significantly ($P<.01$) lower water content.

SOME RELATIONSHIPS OF LIVE ANIMAL AND CARCASS MEASUREMENTS TO CARCASS CHARACTERISTICS AND BREED TYPE DIFFERENCES IN LAMB. A. D. Knight, W. C. Foote and James A. Bennett, *Utah State University, Logan.*

Twenty-six lambs of three breed types (Rambouillet, Suffolk-white face cross, and Southdown) were used. Comparisons were made under uniform finish conditions of high good to low choice. Correlations are simple, pooled-within-breed. Correlations >0.41 are significant ($P<.05$). In general all live animal and carcass measurements concerning size indicated significant breed type differences, Suffolk-cross being intermediate to Rambouillet and Southdown. However, no significant differences were found in percent leg, loin, or breast. Southdown lambs had significantly greater percent rack than Rambouillet or Suffolk-cross, and Rambouillets significantly greater shoulder than Southdown lambs. Percent loin and rack were positively and percent leg negatively associated with percent fat in the 12th rib (0.35, 0.42, and −.51, respectively). Marbling score, specific gravity measurements, and 12th rib cut chemical analysis all suggested a greater amount of intramuscular fat in the Southdown. Specific gravity of the shoulder furnished a good estimate of whole carcass specific gravity ($r=0.87$). The correlation between chemically determined fat and specific gravity of the 12th rib was highly significant (−.70). Significant differences were found in shape but not in total cross-sectional area of the eye muscle. Live animal metatarsus plus tuber calcis length was significantly correlated with eye muscle depth (−.46), width (0.63), and area (0.66). Eye muscle area estimated by a live animal probe technique was significantly correlated with actual eye muscle area (0.53). Significant breed-type differences were not found between percent fat, bone, and lean in the 12th rib cut. The correlation between percent lean and bone was 0.47.

CRIMPED ALFALFA HAY FOR WINTERING BEEF CALVES. Con Bernbeck, Conrad J. Kercher and Clarence F. Becker, *University of Wyoming, Laramie.*

Sixty-three Hereford steer calves were divided randomly. One lot was fed conventionally cured alfalfa and the other fed crimped alfalfa hay *ad libitum*. The steers consumed 8.6 lb. per day of the conventionally cured alfalfa and 8.5 lb. of the crimped. All steers received in addition, an average of 8.9 lb. of corn silage per day during the 140-day trial. The first cutting was fed for 56 days, the second for 56 days, and the third for 28 days. The steers were weighed at 28-day intervals. The method of harvesting did not significantly affect total gains during the winter feeding period. However, when the same cuttings for the two methods of harvesting were compared the steers fed the second cutting of conventionally cured alfalfa gained

63.2 lb. per head, while the steers receiving the second cutting of crimped alfalfa gained 75.3 lb. per head. Rain fell on all of the first cutting and on the conventionally cured second cutting hay. As a result, the conventionally cured second cutting lay in the field two days longer than the crimped hay, which was harvested without rain damage. None of the third cutting was damaged by rain during harvest. It is possible that the differences in feed value of the second cutting as influenced by harvesting methods may have been the result of rain damage.

DIGESTIBILITY OF BLUE GRAMA HAY AND PRODUCTION OF FATTY ACIDS BY SHEEP. K. A. Boller, M. W. Dross, W. W. Repp and W. E. Watkins, *New Mexico State University, University Park.*

The influence upon digestibility of blue grama hay of additives single and in combination was measured with mature wethers. In experiment I addition of 20% corn starch increased digestibility of dry matter ($P<.01$). Ether extract digestion was reduced ($P<.05$) by the addition of brewer's yeast, corn starch, and dicalcium phosphate and was increased ($P<.05$) by the addition of synthetic alfalfa ash. There was no significant interaction among additives. In experiment II a more complete supplement was used in conjunction with rations containing 7, 11, and 15% protein. Urea was used to increase protein content, and the supplement contained 50 gm. corn starch, 46 gm. brewer's yeast, 11 gm. dicalcium phosphate and 48 gm. synthetic alfalfa ash. Addition of the supplement had a highly significant effect ($P<.01$) and the addition of protein had a significant effect ($P<.05$) in increasing digestion of N.F.E. The treatment containing supplement and the highest level of protein increased ($P<.05$) the digestibility of crude fiber and dry matter. It was the protein fraction which mainly contributed to the digestibility of crude fiber, whereas both protein and supplement contributed to the digestibility of dry matter. Protein level and protein supplement interaction influenced ($P<.01$) protein digestion. Total volatile fatty acid production was increased ($P<.05$) by addition of supplement but not by additional protein. There was a close positive relationship between dry matter digestibility and total V.F.A. production. The relative proportions of V.F.A. were unaltered.

EFFECT OF PELLET SIZE AND ROUGHAGE GRIND ON PERFORMANCE OF FATTENING LAMBS. D. C. Church and C. W. Fox, *Oregon State College, Corvallis.*

In two lamb fattening trials the hay incorporated into a high-roughage pellet was ground through various size hammer mill screens. In the first experiment (20 lambs per treatment; 2 replicates) the roughage in the pellet (40% alfalfa hay, 20% grass hay) was ground through 5/32 and 9/32 inch screens. In the second experiment (10 lambs per treatment) the roughage (30% alfalfa hay, 35% grass hay) was ground through 3/32, 3/16 and 1/4 inch screens and incorporated into 1/4, 3/8 and 1/2 inch pellets in a 3 x 3 factorial design. In neither experiment was there any significant affect of fineness of grind on average daily gain, although lot means in each experiment favored the smaller screen sizes. Likewise, there was no significant influence of pellet size, although lot means were slightly higher where the larger pellets were fed.

LAMB RESPONSE TO THREE EXPERIMENTAL FEEDING METHODS. D. C. Church and C. W. Fox, *Oregon State College, Corvallis.*

In two growth trials, wether lambs (Experiment 1, 62 days) and weanling ram lambs (Experiment 2, 46 days) were randomly allotted to one of three experimental feeding methods: (1) stall-fed, (2) individually pen-fed, and (3) group-fed. Pelleted rations were used in each experiment. Statistical analysis of data showed that the

stall-fed lambs gained less ($P<0.01$) than lambs fed by either of the other two methods in each experiment. This was due, in part, to reduced feed consumption by lambs in the stall-fed group. Within treatment variance of average daily gain was markedly reduced by feeding in individual pens.

EVALUATION OF OLEANDOMYCIN IN LAMB FATTENING RATIONS. W. P. Crawford, W. H. Hale, W. C. Sherman, W. M. Reynolds and H. G. Luther, *Chas. Pfizer & Co., Terre Haute, Indiana.*

Preliminary trials have indicated that oleandomycin is effective in increasing weight gains of fattening lambs when fed at 2.0 or 6.0 gm. per ton of total ration (J. Animal Sci. 17:1174, 1958). Two additional lamb trials can now be reported. The lambs were self-fed the following pelleted ration: alfalfa meal 35, cane molasses 7, ground corn 53, urea 1, bone meal 1, bentonite 3. Each treatment group contained 12 lambs, and the control groups were replicated. Both experiments ran for 56 days. Daily rates of gain (lb.) and lb. feed per lb. of gain were: Experiment 1—controls 0.368, 6.84; oleandomycin 2 gm. per ton of ration 0.401, 6.24; oleandomycin 6.0 gm. 0.420, 6.24; oleandomycin 6.0 gm. 0.407, 6.44; oleandomycin 15 gm. 0.469, 5.92; oxytetracycline 15 gm. 0.464, 6.01. Experiment 2—controls 0.308, 10.07; oleandomycin 2 gm. per ton of ration 0.381, 8.69; oleandomycin 6 gm. 0.387, 8.37; oxytetracycline 15 gm. 0.416, 7.62. The oleandomycin in both experiments and at all levels improved rates of gain and feed efficiencies. In Experiment 1, carcass grades were improved in oleandomycin-supplmented groups and the highest level of this antibiotic resulted in the greatest increase in rate of gain and feed efficiency. In Experiment 2, the two levels of oleandomycin produced similar rates of gain and feed efficiencies. In the first experiment, the high level of oleandomycin and oxytetracycline responses were similar; however, in the second, the lower levels of oleandomycin produced weight gains nearly as great as the 15 gm. per ton level of oxytetracycline.

EFFECT OF LOW DOSAGE STILBESTROL IMPLANTS ON GROWTH RATE OF SUCKLING WETHER LAMBS. David C. England, *Oregon State College, Corvallis.*

Nine experiments involving 376 animals have been conducted to determine the response of suckling wether lambs under various production conditions to implantation of 3 mg. of stilbestrol. Implantation was made in the ear. Production conditions included range pastures and improved valley pastures with and without creep feeding. Lambs were individually identified and were weighed at the beginning and end of the experiment. Time on experiment varied from 35 days to 108 days for different groups. Implanted lambs showed nonsignificantly increased average daily gains in each of the nine experiments. Range of increased average daily gain was from 0.01 lb. to 0.09 lb. Average increase in daily gain was 0.047 lb. per day; percentage increase in average daily gain was 9.04. No adverse side effects were noted in live animals.

EFFECT OF IMPLANTED TESTOSTERONE ON GROWTH RATE OF WEANER STEERS WITH AND WITHOUT PREVIOUS STILBESTROL IMPLANTATION. David C. England and Norton O. Taylor, *Oregon State College, Corvallis.*

Thirty-six weaner steers in feedlot were allotted to each of the following hormone treatments: (1) control; (2) 0–30–15 mg. stilbestrol implanted at 0, 92, 182 days respectively on feed; (3) no implant, 450 mg. testosterone and 30 mg. stilbestrol implanted at 0, 92 and 182 days respectively on feed; (4) 30–0–15 mg. stilbestrol implanted at 0, 92 and 182 days on feed respectively; (5) 30 mg. stilbestrol, 450 mg. testosterone and 15 mg. stilbestrol implanted at 0, 92 and 182 days respectively on feed; and (6) 30, 15 and 15 mg. of stilbestrol implanted at 0, 92, and 182 days

respectively on feed. Weights were taken at approximately 28-day intervals. The feeding period was continued for approximately 255 days. All implanted groups gained faster than the control group in each implantation period. Testosterone-implanted animals gained more rapidly in the 90 days subsequent to implantation than groups not implanted with either stilbestrol or testosterone. This was true regardless of whether the animals had been implanted with stilbestrol 92 days prior to testosterone implantation. Animals previously implanted with stilbestrol gained as rapidly when implanted with testosterone as did animals reimplanted with stilbestrol; both gained more rapidly than animals not reimplanted with either hormone. Average daily gains (lb.) for the six treatment groups for the 255-day period were (1) 1.75, (2) 2.05, (3) 1.94, (4) 2.02, (5) 2.03, and (6) 2.06. Implanted testosterone did not increase response to stilbestrol reimplanted 90 days later regardless of whether steers had been implanted with stilbestrol prior to testosterone implantation.

ENERGY AND PROTEIN SUPPLEMENTS WITH ALFALFA RATIONS FOR SWINE REPRODUCTION. A. E. Flower, O. O. Thomas, D. W. Blackmore and K. W. McKenzie, *Montana State College, Bozeman.*

Forty sows and gilts representing Duroc, Montana No. 1, and crossbreds were equalized by breed and age and assigned to two treatments in duplicate lots for spring 1958 farrow. Ten additional females were assigned in a single lot. These were designated as treatment 1, 2 and 3, respectively. Treatment 1 consisted of 50% ground suncured alfalfa hay, and 50% ground barley plus minerals and trace minerals. Treatment 2 differed in that it contained 5% by weight each of soybean and meat meals which replaced equal amounts of barley. Treatment 3 consisted of 80% suncured alfalfa hay, the balance of the ration consisting of animal fat in a carrier of wheat mixed feed fortified with vitamins, minerals, and trace minerals. When treatments 1 and 2 were compared in weight changes pre-and post-farrowing, highly significant differences occurred with respect to ration, breed, and interaction. Females on ration 1 gained more weight pre-farrowing, and lost more from that time to weaning. There was a non-significant trend for litters to be both heavier and to contain more pigs at weaning in treatment 1. The trend in treatment 3 was for less gain pre-farrowing, more loss thereafter to weaning, and less total litter weight at 8 weeks. Pre-farrowing daily feed consumption was 7.6 lb., 8.0 lb., and 4.7 lb., respectively, per female for the three treatments. Production characteristics followed similar trends to those obtained the previous year on rations essentially the same as rations 1 and 2.

EFFECT OF VARIED RATIOS OF UREA TO BIURET ON NPN UTILIZATION BY SHEEP AND BEEF CATTLE. U. S. Garrigus, E. E. Hatfield, A. L. Newmann, R. M. Forbes and K. M. McKee, *University of Illinois, Urbana.*

The number of lambs in metabolism trials and the rations fed were as follows: A, 12 lambs fed a low nitrogen basal ration plus 2.6% urea; B, 12 fed the basal plus 1.95% urea and 0.81% biuret; C, 8 fed the basal plus 1.3% urea and 1.62% biuret; D, 12 fed the basal plus 0.65% urea and 2.43% biuret; E, 12 fed the basal plus 3.24% biuret; F, 8 fed the basal plus 3.0% cyanuric acid; and, G, 8 fed the basal without additional nitrogen. The average apparent digestion coefficients for dry matter and nitrogen, and the average daily nitrogen balance, in grams, respectively, were: A-70.8, 75.5, 7.6; B-69.4, 73.1, 5.0; C-69.1, 72.6, 5.7; D-69.2, 73.6, 4.8; E-65.1, 76.2, 8.5; F-60.9, 60.3, 5.2; and G-59.7, 39.0, 1.5. In a metabolism trial with six steers a semipurified, high-roughage, feed mixture containing 0.44% nitrogen was fed twice daily supplemented once daily with a supplement in which 80% of the nitrogen was furnished by various levels of urea and biuret. All steers received all rations at some time during the trial. The basal feed mixture was, in parts: dehydrated ground

corncorbs, 50; corn starch, 20; molasses, 5; alfalfa meal, 5; and, complete mineral mix, 4. The three supplements were: Supplement A, urea 2.4; biuret 1.0, starch 0.6, and ground corn 20.0; Supplement B, urea 1.6, biuret 2.0, starch 0.4, and ground corn 20.0; Supplement C, urea 0.8, biuret 3.0, starch 0.2, and ground corn 20.0. All supplements were fortified with 14 mg. of aureomycin per lb. of supplement. The average apparent digestion coefficients of dry matter, energy and nitrogen, and the average daily nitrogen balance in grams were: A-66.2, 63.0, 63.7, 15.7; B-64.4, 61.2, 63.7, 18.1; and C-64.7, 61.6, 64.0, 18.3.

NUTRITIONAL EVALUATION OF NITROGEN FERTILIZED MOUNTAIN MEADOW HAY. L. L. Hopkins, Jr., F. C. Daugherty and C. D. Story, *Colorado State University, Fort Collins.*

Sixteen Hereford heifers consuming nitrogen fertilized mountain meadow hay for a 147-day feeding period during the winter of 1957-58 gained 0.73 lb. per day while a simlar group fed non-fertilized mountain meadow hay gained 1.00 lb. per day. The following winter in a 117-day feeding period nine Hereford heifers consuming nitrogen fertilized hay gained 1.04 lb. per day while the control group gained 1.22 lb. per day. The digestibility of these hays, determined in digestion trials with sheep, was as follows: Nitrogen fertilized hay—dry matter 65.6%, protein 67.1%, crude fiber 75.5%, nitrogen-free extract 59.8%, ether extract 48.9% and ash 53.3%; non-fertilized hay—dry matter 66.3%, protein 62.1%, crude fiber 78.3%, nitrogen free extract 61.2%, ether extract 19.2% and ash 49.9%. A comparison of the two hays in an artificial rumen, using gas production as a measure of total microbial activity, has indicated greater gas production from the non-fertilized hay fermentation. To date rabbit feeding trials have been inconclusive in terms of weight gains. A difference in nutritional value of these hays is indicated but not explained by the apparent digestibilities and artifical rumen fermentations. Therefore, the difference in animal gain may be due to a physiological disturbance caused by the nitrogen fertilization of mountain meadow hay, but not necessarily due to the nitrogen in the hay.

OXYTETRACYCLINE AND HIGH LEVELS OF PHOSPHOUS IN THE WINTERING RATION OF BEEF CATTLE. Farris Hubbert, Jr., Joe D. Wallace, W. P. Skelton and W. A. Sawyer, *Squaw Butte-Harney Experiment Station, Burns, Oregon.*

Forty Hereford weaner cattle were assigned to a 126-day 2 x 2 factorial study of the influence of the addition of 75 mg. oxytetracycline (Tm) and/or 5 gm. phosphorus (provided as bone meal) to a daily wintering ration. The animals were fed in 4 lots of 10 head each and received a basal ration of meadow hay *ad libitum*, 2 lb. of barley, and 1 lb. of cottonseed meal. The meadow hay consisted primarily of rush (*Juncus* spp.) and sedge (*Carex* spp.) with minor amounts of grass and native clover. The basal ration contained 10.0% crude protein and 0.18% P. The addition of 5 gm. P increased the P content of the ration to 0.26%. After 71 days on trial average daily gains were: Basal, 1.25; Basal + P, 1.27; Basal + Tm, 140; Basal + P & Tm, 1.47. The antibiotic addition had resulted in a significant ($P<0.05$) increase in rate of gain. At the end of the 126-day study the average daily gain and lb. feed required per lb. gain, respectively, was: Basal, 1.43 + 9.36; Basal + P, 1.44 + 9.51; Basal + Tm, 1.49 + 9.05; Basal + P & Tm, 1.56 + 8.65. There were no statistically significant differences in rate of gain at the end of the trial although the antibiotic fed groups maintained a consistent advantage throughout the study. The apparent response due to the addition of the antibiotic or combination of the antibiotic and P appeared early in the feeding period followed by excellent performance in all lots.

HIGH MOLASSES RATIONS FOR GROWING AND FATTENING SWINE. I. I. Iwanaga, K. K. Otagaki, Estel Cobb and O. Wayman, *University of Hawaii, Honolulu.*

Four feeding trials were carried out involving 182 feeder pigs weighing less than 100 lb. which were divided into groups of equal numbers. Each group was placed in a concrete drylot pen provided with water bowls. The animals were hand-fed twice a day. In trials I and II, rations containing 30% molasses were used for pigs up to 120 lb. body weight; thereafter 40% molasses rations were fed. Average daily feed in trial I and II ranged from 4.70 to 5.42 lb. for hogs weighing 140 to 200 lb. liveweight at the time of slaughter. Feed efficiency ranged from 3.41 to 4.00 lb. of feed per lb. of gain. Throughout trial III, 30% molasses was fed and the fiber content of the ration was increased. Rate of gain and feed efficiency decreased. There appeared to be a relationship between source of fiber and feed efficiency. In trial IV, two high level molasses rations fed according to trial I and II were compared with a commercial feed mixture fed according to the manufacturer's recommendations. Average daily gains for the molasses and commercial rations were 1.32 lb., 1.30 lb. and 1.29 lb. with feed efficiencies of 4.07, 4.06 and 3.73 lb. respectively. Digestibility tests with young, growing hogs showed that molasses fed at 10, 20, and 30% levels had TDN values of 63.0, 63.3, and 65.2%, respectively.

THE USE OF TRANQUILIZERS FOR FAT BEEF CATTLE GOING TO SLAUGHTER. Conrad J. Kercher, *University of Wyoming, Laramie.*

The purpose of this study was to test the value of a tranquilizer for fat cattle going to slaughter. In trial I, 18 long yearling heifers were randomly divided, one group receiving the tranquilizer 12 hours before slaughter. The heifers were trucked 3 miles to slaughter. In trial II, 54 two-year-old steers were randomly divided, one group being tranquilized 46 hours before slaughter. The steers were trucked 425 miles to slaughter and were in transit for 13 hours. In both trials, 50 mg. of ethyl isobutrazine (Diquel) per 200 lb. of body weight were administered intraperitoneally. The animals did not receive any feed after the administration of the tranquilizer. The control heifers lost 0.75% more weight prior to slaughter than the treated heifers. The treated heifers were not any easier to handle just prior to killing. The dressing percentage and cooler shrink of the treated heifers were not appreciably different from the controls. The control steers lost 0.5% more weight in transit than the treated. The yield and cooler shrink of both groups were similar. Three carcasses from the control steers but none from the treated were bruised.

HORMONE IMPLANTS FOR SUCKLING CALVES. Conrad J. Kercher and Robert C. Thompson, *University of Wyoming, Laramie.*

The purpose of this study was to test the effectiveness of hormone implants for suckling beef calves. Sixty steer calves were randomly allotted to the following treatments: controls, 3 mg. stilbestrol (DES), 6 mg. DES, 12 mg. DES, and one-half Synovex-S implants. Sixty-three heifer calves were randomly allotted to the following treatments: controls, 3 mg. DES and one-half Synovex-H implants. All calves were weighted, tattooed, and implanted at the base of the ear at branding time when they were from a few days to six weeks of age. The cows and calves were summered on native range comprised of foothill and meadow bottom vegetation. In the fall the calves were weighed and scored for straightness of top line and feeder grade. The implantation of 3 mg. of DES in either heifer or steer calves did not appreciably alter summer gain. All other hormone implants in either heifers or steers increased summer gains, although not significantly. The straightness of the topline was not altered significantly, and feeder grade was not influenced by hormone treatment.

IMPROVEMENT OF BARLEY RATIONS FOR SWINE. I. EFFECTS OF WATER TREATMENT AND ENZYME SUPPLEMENTATION. L. M. Larsen and J. E. Oldfield, *Oregon State College, Corvallis.*

Ninety-eight weaner pigs were involved in three experiments to test the effectiveness of amylolytic enzyme additions and water treatment on barley rations in terms of growth rates and feed conversion. Both an unsupplemented barley and a corn control ration were included. The corn ration significantly improved weight gains and feed efficiency over the barley control. Addition of 0.5 and 2.0 gm. amylolytic enzyme preparation (Merck) per lb. resulted in a non-significant trend towards increased weight gains and feed efficiency, particularly in younger, lighter pigs. Use of 1.13 g. per lb. of MK-124 (Merck) amylolytic preparation did not significantly improve weight gains or feed efficiency. Soaking barley in the whole kernel followed by drying before mixing likewise did not improve performance; however, addition of 2.5% barley malt followed by soaking and drying improved weight gains and increased efficiency of feed use. When 10% barley malt was added, palatability appeared to be lowered, and feed intake decreased. Utilization of the soaked barley ration with the 10% added malt tended (non-significant) to be improved. Addition of 0.5 g. per lb. HT-440 amylase preparation (Takamine) did not increase gains nor improve feed conversion. These experiments suggest little advantage to supplementation of dry barley rations with these enzyme preparations, but indicate a possible benefit from a combined enzyme (barley malt) addition and water treatment.

DEVELOPMENT OF TECHNIQUES FOR EVALUATING GRAZED FORAGE. A. L. Lesperance, V. R. Bohman, D. W. Marble, E. H. Jensen and Robert Madsen, *University of Nevada, Reno.*

The purpose of this study was to develop suitable biological sampling techniques with steers to estimate the nutritive value and composition of consumed forage. Techniques were developed for sampling grazed forage by means of both esophageal and rumen fistulas. Prior to sampling, the rumen and reticulum of rumen-fistulated steers were completely emptied; after sampling, the rumen contents were replaced. A simple bag placed around the neck of an esophageal-fistulated animal was used for collection. Comparisons of feeds of known composition with samples of these same feeds collected through fistulas indicated some changes in composition. Ash increased in similar quantities in both rumen-and esophageal-collected samples ($2.71\% \pm 0.35\%$); nitrogen-free extract decreased ($2.96\% \pm 0.85\%$), and protein, energy, ether extract and calcium remained constant. Phosphorus was significantly greater in rumen samples ($0.18\% \pm 0.03\%$) than in esophageal-collected samples ($0.12\% \pm .02\%$). Crude fiber decreased in collected samples on alfalfa hay but increased on grass hay collections. In pasture studies with rotation grazing, protein decreased an average of 4.7% during the grazing period (2–3 weeks) in several trials; crude fiber increased 4.9% and energy decreased slightly, but other constituents remained constant. The percent grass increased and the percent clover decreased in collected samples indicative of selective grazing during the grazing period.

EFFECTS OF STILBESTROL IMPLANTS AND TRANQUILIZERS ON RATE OF GAIN, SHRINK, YIELD AND CARCASS GRADES OF BEEF STEERS. P. T. Marion, *Texas Agricultural Experiment Station, Spur.*

Steers weighing 750 lb. were implanted with 36 mg. of stilbestrol per head in two trials. Daily gains of the implanted steers averaged 2.79 lb. compared with 2.39 lb. for those in the control group. Hydroxyzine fed at a level of 5 mg. to half of the implanted steers in the first trial did not increase gains, but a level of 2.5 mg. fed to half of the implanted steers in the second trial increased daily gains from 2.52 lb.

to 2.72 lb. Implanted steers graded 1/3 grade (USDA) lower than the control group in each trial, but the tranquilizer had no effect on carcass grade. In the first trial, 15 steers were fed 45 mg. of hydroxyzine prior to shipment to market. These steers shrank 0.4% less and dressed 0.4% more than the untreated steers. Those fed either 50 or 100 mg. of hydroxyzine per head in the second trial had no advantage in shrink or yield over the untreated steers. Another tranquilizer, PVD-1, was injected at 2 mg. per cwt. into 10 steers and fed at a level of 100 mg. to another group. The injection treatments did not reduce shrink to market; however, the treated steers dressed 0.6% higher. The steers fed PVD-1 shrank 0.8% less and dressed 0.2% higher than the control group. Tranquilizers showed some advantage in these trials.

GROUND MESQUITE WOOD AS A ROUGHAGE FOR YEARLING STEERS. P. T. Marion, C. E. Fisher and E. D. Robison, *Texas Agricultural Experiment Station, Spur.*

Mesquite (Prosopsis juliflora) infests 70 million acres of grassland in the Southwest. This brush plant reduces forage production on pastures and makes cattle-work more difficult. Wood from green mesquite stems 1 to 3 in. in diameter can be chipped, ground and fed in rations for beef cattle. Mesquite meal contains approximately 6% protein, 35% N.F.E., 48% fiber and 30 ppm. carotene. Two 450-lb. calves consumed 6 lb. mesquite wood with 6 lb. concentrates in an 86-day preliminary trial in 1954. Their daily gains averaged 1.35 lb. compared with 1.54 lb. for calves fed cottonseed hulls instead of mesquite wood. Daily gains of 2.2 lb. were made the next year in a 140-day trial by 645-lb. steers fed 7.2 lb. mesquite wood, 1.9 lb. hulls, 2 lb. alfalfa and 10 lb. concentrates. Steers in the control group fed cottonseed hulls gained 2.3 lb. daily. In the third trial, eight steers averaging 873 lb. made daily gains of 2.54 lb. and consumed 12.2 lb. mesquite wood, 3.5 lb. sorghum fodder, and 15.5 lb. concentrates. At the end of the 112-day period they were consuming 16 lb. mesquite wood with 2 lb. cottonseed meal, 4 lb. molasses, and 10 lb. grain. Cows were also maintained 140 days on a mesquite wood ration. They calved normally and were in better condition than cows fed cottonseed hulls.

HYGROMIX AS A HOG WORMER. C. O. Miller and O. O. Thomas, *U. S. Range Livestock Experiment Station and Montana Agricultural Experiment Station, Bozeman.*

Four hundred and ninety-one, 3-week-old pigs and their dams were grouped on alfalfa pasture at the U. S. Range Livestock Experiment Station, Miles City, Montana. The creep ration for 167 pigs on Yorkshire sows contained 5 lb. of Hygromix per ton; that for the other 324 pigs on Montana No. 1 gilts and sows contained none. At 56 days of age, 38 of the Yorkshire pigs were selected for record of performance testing in drylots. Hygromix was continued in their rations until they averaged 145 lb. At the same age, 119 Montana No. 1 pigs were selected for the tests and Hygromix was again omitted in their ration. The feed for both groups on test and the creep feed contained chlortetracycline. Sodium fluoride was used to expel worms from both the Yorkshire and Montana No. 1 pigs at 11 weeks of age and again at 20 weeks. The pens were carefully checked after each worming for the number and relative size of the worms expelled. The effectiveness of Hygromix for prevention of worms was based on the number of worms recovered after each treatment with sodium fluoride. Hygromix was very effective in controlling worms in the 38 Yorkshire pigs, only 13, 0.3 per pig, immature worms being recovered. From the 119 Montana No. 1 pigs, 515 worms, 4.3 per pig, were recovered. Over four times as many worms were recovered at 11 weeks as at 20 weeks of age, indicating that more protection is needed during the suckling period than later in life. Hygromix feeding did not depress nor improve the rate of gain or feed efficiency.

THE VALUE OF AMMONIATED BAGASSE PITH IN RUMINANT NUTRITION. Paul Shimabukuro and K. K. Otagaki. *University of Hawaii,* and Wayne H. Hilton, *Hawaiian Sugar Planters' Assn. Experiment Station, Honolulu.*

Sixteen growing heifers were allotted at random to two levels of ammoniated pith in two replicates. Six Holstein-Friesian milking cows were used on a double change-over design to evaluate ammoniated pith as a source of protein for milk production. Both of these studies failed to show that ammoniated bagasse pith holds promise of becoming an important non-protein nitrogen feed for growth and milk production. The results indicate that dairy cattle can utilize the nitrogen in ammoniated pith for growth and milk production; however, the feed efficiency data indicated higher total feed requirements per lb. of body weight gain and milk production than when control rations containing a natural source of protein were fed. Digestibility studies with two steers and four wethers are in agreement with the idea that digestible protein values of non-protein nitrogenous products are lower than those of natural protein supplements. Total digestible nutrient values were not enhanced with ammoniation although others have suggested that ammoniation under pressure and heat may have a beneficial effect on lignin-cellulose complex digestibility. No harmful side effects from feeding ammoniated bagasse pith were observed.

EFFECT OF A TRANQUILIZER, DYNAFAC, BACITRACIN AND PHOSPHORUS IN WINTERING RATIONS FOR WEANED HEIFERS. O. O. Thomas, *Montana Agricultural Experiment Station, Bozeman.*

Four hundred and eighty weaned Hereford heifers were divided into six lots of 80 head each. All lots were group-fed and each heifer consumed an average of 1 lb. of a grain pellet containing 2.5% fat, 1 lb. of barley, and an average of 12.5 lb. of chopped alfalfa, from November 19, 1958 to February 14, 1959. From then until the completion of the trial on March 28, an additional 2 lb. of barley was fed. Lot 1 heifers served as the control, the ration fed Lot 2 contained a tranquilizer, (2.5 mg. fed per heifer) Lot 3, tranquilizer plus added phosphorus, Lot 4, tranquilizer plus Dynafac (0.5 gram fed per heifer) and Lot 5, tranquilizer plus Dynafac and phosphorus. The ration fed Lot 6 contained only bacitracin; this lot was started on bacitracin. The heifers averaged about 420 lb. at the start and about 575 lb. at the end of the 129-day wintering period. Daily gains for heifers during the winter for the respective lots were 1.21, 1.20, 1.28, 1.17, 0.97, and 1.27 lb. Heifers fed a tranquilizer plus phosphorus and those fed bacitracin made the greatest total winter gains. However, during the last 41 days when the grain ration was increased, the average daily gains were 1.88, 1.62, 1.52, 1.74, 1.71 and 1.92 lb. respectively. The tranquilizer tended to decrease gains during the last 41 days. Of the tranquilizer-fed lots, the addition of Dynafac gave the greatest increase in gains. Heifers fed bacitracin made the greatest increase in gains in the last 41-day period.

LEVEL OF FAT AND WHEAT MIXED FEED IN PELLETED SWINE FATTENING RATIONS. O. O. Thomas, H. A. Jordan, J. A. Marchello and A. E. Flower, *Montana Agricultural Experiment Station, Bozeman.*

Two levels of fat, 0 and 2.5%, and three levels of wheat mixed feed, 0, 25, and 50%, were incorporated into pelleted rations and fed to replicated lots of Montana No. 1—Duroc feeder pigs. Average starting weight of pigs was 75 lb. in the light replicate and 92 lb. in the heavy replicate. The pigs were fed a 17% protein ration until they reached 125 lb. and then a 13% protein ration until they reached about 210 lb. A barrow and a sow were selected at random from each treatment for carcass studies. Lot 1 was fed a high barley ration; Lot 2, the same ration plus 2.5% added fat; Lot 3, the 25% wheat mixed feed ration; Lot 4, the same ration plus 2.5% added fat; Lot 5, a 50% wheat mixed feed ration, and Lot 6 the same plus 2.5%

added fat. Total average daily gains for the total period for the heavy replicate were 2.18, 2.28, 1.90, 1.98, 1.95 and 1.81 lb., respectively, and for the light replicate, 2.05, 1.96, 1.88, 1.90, 1.76 and 1.72 lb., respectively. Fat added to the ration of the heavy replicate increased the daily gain at all three levels of wheat mixed feed but improved the feed efficiency only at 0 and 25% levels. Fat added to the ration of the light replicate did not improve the daily gain but did improve the feed efficiency at all three levels of wheat mixed feed. Wheat mixed feed in the ration of light and heavy hogs tended to decrease the daily gain and feed efficiency. Specific gravity of the carcasses indicated that added fat produced fatter carcasses in heavy feeder hogs than in light feeder hogs.

EFFECT OF HORMONE IMPLANTS IN STOCKER STEERS AND SUBSEQUENT FEEDLOT GAINS. Robert C. Thompson and Conrad J. Kercher, *University of Wyoming, Laramie.*

During the 142-day summer phase of this study, 119 yearling Hereford and Angus steers were randomly allotted to three groups. Fifty-one of the steers served as controls (Group I), 34 were implanted with 24 mg. of stilbestrol (DES) (Group II) and 34 were implanted with Synovex-S (Group III). At the beginning of the feedlot phase, the steers were further divided into seven groups. One-third of the steers from Group I served as controls, one-third received an initial 24-mg. DES implant and the remainder were implanted with Synovex-S. One-half of the steers from Groups II and III were re-implanted with the same hormone that they had previously received. During the summer phase, hormones increased the rate of gain on native short-grass range (not significant). Steers initially implanted at the start of the 120-day feedlot phase, and the steers receiving the double implants made faster gains in the feedlot than either the controls or the steers that received implants during the summer phase only (highly significant). The feedlot gains of steers implanted with Synovex-S or DES were approximately equal. The gains of the control steers (no hormone implants) were essentially the same as the gains of the steers that had received only one implant during the summer phase. The steers that received an initial implant at the start of the feedlot phase gained slightly faster (not significant) than the steers receiving the double implants. The same trends were noted during the total 262-day trial. Synovex-S implants produced significantly greater gains than DES implants. The gains of steers receiving one implant during the summer phase were not different from the controls. The steers that received implants during the feedlot phase, regardless of previous summer treatment, made faster gains than either the controls or the steers that received only one implant during the summer phase (highly significant). The total gains of steers receiving only one implant in the feedlot were similar to the gains of steers receiving the double implants.

RELATIVE VALUE OF DIFFERENT ESTROGENS AND ESTROGEN-STEROID COMBINATIONS UPON GROWTH IN BEEF CATTLE. H. E. Thurber, H. T. Strong and M. T. Clegg, *University of California, Agricultural Extension Service, El Centro and the School of Veterinary Medicine, Davis.*

Eleven trials were conducted to determine the value of different estrogens or estrogen combinations relative to a 30-mg. implant of diethylstilbestrol (DES). A total of 1326 animals were used of which 117 were heifers. Most of the animals were either Hereford or Hereford Brahman crossbreds, ranging in age from 1 to 2 years. In all except one trial, the ration was high concentrate, low roughage. Treatment consisted of implantation of a 30- or 15-mg. DES pellet; feeding of 10 mg. DES per head daily; implantation of 20 mg. estradiol plus varying levels of progesterone ranging from 100 to 1000 mg., or 20 mg. estradiol benzoate plus 200 mg. testosterone propionate; and implants of 25 mg. hexestrol, or varying levels of hexestrol in com-

bination with different levels of testosterone and hydrocortisone. In heifers, the response was variable. In some, no significant effect on growth was obtained; in others, significant increases in gain amounting to as much as 20% over untreated controls were observed. No single estrogen treatment proved superior to any other with respect to gain. Thirty-mg. DES implants caused the highest incidence of enlarged udders. In steers, hexestrol implantation produced the highest gain. There was no difference among groups implanted with estradiol-progesterone, hexestrol-testosterone, or DES, with respect to gain or carcass effect. Generally, the groups showing the greatest increase in gain, showed the greatest reduction in carcass grade.

EFFECT OF ROTATIONAL GRAZING ON ANIMAL NUTRITION. D. T. Torell and W. C. Weir, *University of California, Davis.*

Esophageal fistulated sheep were used to sample forage in a study conducted to evaluate the change which occurs in the chemical composition of forage which sheep consume when moved from a grazed to an ungrazed pasture. Eight pastures, four consisting of improved-fertilized range and four consisting of unimproved-native range, were used in the study. Sheep were rotated within each pasture type. Samples were analyzed for crude protein, crude fiber, lignin, ether extract, and silica-free ash. The crude protein content of forage consumed by sheep changed abruptly when sheep were moved from the grazed to the ungrazed pasture. The crude fiber content in five of the six grazing periods increased with grazing in the improved pastures; in contrast, it decreased in all except the first of the grazing periods in the unimproved pastures. The lignin fraction was erratic and ether extract showed no definite trend. Silica-free ash determination is meaningless without the use of a saliva tracer. Analyses indicated that the chemical composition of grazed forage changed abruptly when sheep were rotated between pastures. A change also occurred during the grazing period in a given pasture.

RESPONSE OF BEEF CATTLE TO PELLETED AND COARSELY CHOPPED MOUNTAIN MEADOW HAY WITH DIGESTIBILITY COMPARISONS. Joe D. Wallace and Farris Hubbert, Jr., *Squaw Butte-Harney Experiment Station, Burns, Oregon.*

Six Hereford steer calves averaging 365 lb. were individually fed a ration consisting solely of mountain meadow hay for an 84-day wintering period. The hay consists principally of rush (*Juncus* spp.) and sedge (*Carex* spp.) with minor amounts of grass and native clover. Three calves received the hay in a coarsely chopped form while the other three received hay from the same stack ground through a 5/32 inch screen and processed into 3/4 inch pellets. Both forms of hay were fed *ad libitum*. Average daily gains on the chopped and pelleted hays were 0.31 and 1.61 lb., respectively. Pelleted hay was consumed at a rate of 3.26 lb. per 100 lb. body weight as compared to 2.48 lb. for the chopped hay. Total fecal collections were made on all animals during two 5-day periods. The digestibility of dry matter was 54.8% and 54.0% for the chopped and pelleted hays, respectively. Cellulose digestibility was 66.7% for the chopped and 56.8% for the pelleted hay, the difference being significant ($P<0.01$). Digestible energy was 1.09 therms per lb. for the chopped hay and 1.06 therms per lb. for the pelleted hay.

INFLUENCE OF WINTER CONDITIONS ON THE FEED AND WATER INTAKE OF FEEDLOT STEERS. C. M. Williams, *University of Saskatchewan, Saskatoon.*

Thirty-six yearling Hereford steers were allotted to the following treatments: Lot 1—no shelter (page wire fence), no bedding; Lot 2—no shelter, straw bedding; Lot 3—baled straw shed, straw bedding; Lot 4—baled straw shed, no bedding;

Lot 5—board fence shelter, no bedding; Lot 6—board fence shelter, straw bedding. Daily feed intake by lots and daily water intake and continuous air temperatures by shelter treatment were recorded. The range in air temperature for the period Nov. 1, 1957 to February 21, 1958 was — 35° F. to + 45° F. Feed intake varied with changes in air temperature but there was not a significant correlation between them. Feed intake was significantly correlated (r=0.25) with water intake for the following day. Water intake was significantly correlated with air temperature (r=0.27) on the same day. The individual treatments did not affect feed and water intake but did significantly affect rate and efficiency of gain. It was concluded that large, rapid changes in air temperatures result in variations in feed intake (usually a depression) and variations in water intake which rise and fall with temperature and with feed intake the preceding day. A low fluctuating temperature is a greater problem in steer feeding than a low constant temperature.

BLOOD COMPOSITION IN WHITE MUSCLE DISEASE. Clifton Blincoe, *University of Nevada, Reno.*

Spontaneous cases of white muscle disease of lambs occurring on several western Nevada ranches have been studied to characterize some of the blood changes induced by this disease. Blood serum analyses included glutamic-oxalacetic transaminase, lactic dehydrogenase, acid phosphatase, alkaline phosphatase, cholinesterase, total protein and glycoprotein. Whole blood analyses included non-protein nitrogen, glucose, and creatinine. The analyses were made by standard methods of clinical chemistry. Serum glutamic-oxalacetic transaminase, lactic dehydrogenase, glycoprotein, and non-protein nitrogen increased significantly. Total protein, creatinine and acid phosphatase did not change. Alkaline phosphatase decreased significantly. True cholinesterase was not found in the blood serum of lambs. The clinical chemical changes were consistent with a non-specific breakdown of the blood-muscle barrier and associated catabolism of muscle protein.

EFFECTS OF RED CLOVER ON REPRODUCTION IN SHEEP. C. W. Fox, F. F. McKenzie and J. E. Oldfield, *Oregon State College, Corvallis.*

Starting August 19th, 27 ewes were pastured on red clover 17 days prior to when they were joined with rams, and remained on red clover with the rams for 60 additional days during the breeding period. Only 14 of the 27 ewes lambed from conceiving on the red clover pasture; thereby resulting in 48% dry ewes. The 14 ewes that lambed conceived in the following 17-day estrous cycles after joining with the rams: 50% first cycle, 43% second cycle, 0 third cycle, and 7% fourth cycle. Concurrently 13 control ewes were kept on irrigated pastures consisting primarily of grass and very little Ladino clover for 17 days prior to joining with rams, and 60 additional days during the breeding period. All except two of the 13 ewes lambed. These ewes lambed from conceiving in the following 17-day estrous cycles after joining with the rams; 91% first cycle and 9% second cycle. All ewes that did not lamb from pasturing on red clover exhibited normal estrous cycles as indicated by acceptance of a ram every 16 to 20 days during the breeding period. All ewes were gaining in body weight at the time of joining with the rams. Before joining the ewes, the semen from all rams was examined microscopically and considered to be of excellent quality as indicated by motility, number of live sperm and sperm morphology.

REPRODUCTIVE FAILURE IN THE SOW. E. S. E. Hafez, *State College of Washington, Pullman.*

Sixty Palouse gilts were checked, prior to puberty, daily with vasectomized boars for 6 months and 4 gilts for 12 months. Forty-two gilts were mated and slaughtered

38 to 100 days post coitum; fetuses were dissected. Delayed puberty (over 240 days) occurred in 8.35% of the gilts. All estrous cycles ranged from 17.4 to 23.6 days. Silent heat occurred in 9.61% of the recorded cycles and was not related to a particular season of the year. The gilts which required two or three services per conception averaged 15%. This was positively related to backfat thickness. Prenatal mortality seemed to occur at two peaks, at implantation and at organogenesis. A fetal defect was observed in five litters traced to two boars; the fetuses had subcutaneous dorsal vesicles, but showed no embryological abnormalities. Five patterns of fetal mortality were observed. (1) extra-embryonic anomalies, (2) endo-embryonic anomalies such as reabsorption, muscular dystrophy, umbilical hernia, detached umbilical cord or hydrocephalus, (3) embryonic degeneration associated with physiochemical changes in fluids or chorionic villi, (4) varying degrees of reabsorption of conceptus, (5) degeneration of whole litter. Fetal mortality was not related to sequence in uterine horns or to number of implantations.

PHYSIOLOGICAL PROPERTIES OF SWINE BLOOD AS RELATED TO NUTRITIONAL ENVIRONMENT AND MUSCLING QUALITIES OF CARCASS. E. S. E. Hafez, R. E. Mauer and M. E. Ensminger, *State College of Washington, Pullman.*

Palouse gilts were divided into two groups; one group was full-fed from weaning to 150 lb. and the other group was fed only 70% this amount. After six generations, one-half of the pigs in each group were shifted to the other plane of nutrition, thus forming four groups: high-high (HH), low-low (LL), low-high(LH) and high-low (HL). F_{10} gilts were slaughtered; prior to slaughter, three blood samples were drawn for determination of hematological values and serum creatinine. The weight of defatted ham and of thyroid were recorded. Half of the carcasses were completely dissected to lean, fat, bone and glands. Correlations were computed. The carcass bone:fat:lean ratios ranged from 1:2.44:4.17 to 1:10.37:6.96. The long-term controlled plane of nutrition had no significant effect on any of the blood physiological properties studied. Lean:fat ratio of carcass was negatively correlated with sedimentation rate. Hemoglobin and red count were not correlated to muscling properties. The thyroid weight was correlated with white count and with hematocrit. Serum creatinine was correlated to average daily gain, weight of lean in ham and to weight of defatted ham.

PREDICTION OF BODY SURFACE AREA IN THE PIG—MATHEMATICAL AND PHYSIOLOGICAL FUNCTIONS. E. S. E. Hafez, T. S. Russell and M. E. Ensminger, *Washington Agricultural Experiment Station, Pullman.*

Twelve gilts of different live weights were slaughtered, processed and skinned. The surface area of skin of eight body regions was measured by planimetry. Simple and multiple correlations were made between total surface area and body measurements, live weight and back-fat thickness. Total body surface area ranged from 1867 to 3129 sq. in. with an average of 2605. The skin surface area of the head, jowl, Boston butt, picnic ham, loin, bacon, ham and feet including tail was 235, 152, 158, 314, 401, 621, 517 and 208 sq. in. The total skin surface area was significantly correlated with back fat ($P<0.05$) and all body measurements on foot ($P<0.01$). The highest correlation coefficient was 0.84 for surface area and middle circumference. The regression equation is: $Y=714X-968.5$ (Y=skin surface in sq. in. and X=middle circumference in.) The lowest correlation coefficient was 0.61 for back fat. Several multiple correlations were determined with little improvement over the value obtained for the middle circumference and surface area. The psysiological functions of surface area are discussed in relation to metabolic rate, heat resistance and adaptability to cold.

MODIFIED SUMMER ENVIRONMENT AND GROWING SWINE. Hubert Heitman, Jr., C. F. Kelly, T. E. Bond and LeRoy Hahn, *University of California and U. S. Department of Agriculture, Davis.*

The experiment involved 48 growing-finishing pigs raised in confinement under California summer conditions. The average diurnal temperature range was 58.5 to 94.4° F. with an average mean temperature of 75.0° F. The following treatments were compared to a control lot (all lots had shade): wallow in the sun, wallow in the shade, wallow combined with increased air motion, a small air-conditioned house, and confinement to a small pen inside a large hog barn. During 50 days of the 70-day experimental period, observations were made every two hours (from 8:00 a.m. to 4:00 p.m.) on the use of heat relief measures. Over the 70-day period all treated groups gained weight more rapidly than the controls, but there were no significant differences among treatments. Food utilization appeared poorest in the control group and best in the group having access to the air-conditioned house. Where shade was the only heat relief measure provided (control group), average use for the 50-day period was about 90% of the time for dry bulb temperatures between 69 and 99° F. Addition of a wallow decreased the time spent in the shade and increased the time spent eating during the day. The air-conditioned house was used 60% or more of the time during the day for temperatures between 69 and 99° F. Use of heat relief measures increased rapidly as the temperature went above 70° F.

EFFECT OF INJECTABLE IRON AND ORAL OXYTETRACYCLINE ON HEMOGLOBIN, PACKED CELL VOLUME AND RATE OF GAIN OF BABY RANGE CALVES. Farris Hubbert, Jr. and Joe D. Wallace, *Squaw Butte-Harney Experiment Station, Burns, Oregon.*

Sixteen Hereford calves were randomly assigned to a 2×2 factorial study of the influence of a 10-ml. injection of iron dextran (Armidextran) shortly after birth and/or daily oral administration of 50 mg. oxytetracycline. Hemoglobin and packed cell volume determinations were made on all calves at birth and at weekly intervals to 4 weeks of age. The calves remained with their dams which were fed a ration of meadow hay *ad libitum,* and one lb. of cottonseed meal daily. The treatments were (1) control, (2) iron dextran injection, (3) oral oxytetracycline, and (4) iron injection plus oral oxytetracycline. Average hemoglobin content for the control group at weekly intervals from birth through 4 weeks of age was 13.7, 11.0, 10.6, 9.8, and 10.2 gm. %. The iron injection significantly ($P<0.05$) reduced the drop in hemoglobin content at 1 and 2 weeks of age. The influence of the injection diminished after the second week. Oral administration of the antibiotic appeared to result in an increase (not significant) in hemoglobin at the third week. The group receiving the combination of iron and antibiotic had the smallest decrease in hemoglobin following birth. Average hemoglobin content for the treatment groups at 2 weeks of age was (1) 10.6, (2) 13.1, (3) 11.4, (4) 12.8 gm. %. Packed cell volume followed similar trends. Average lb. of body weight gain from birth to 4 weeks of age was (1) 48.2, (2) 57.2, (3) 58.0, (4) 55.2. There was some evidence of a relationship of higher hemoglobin and packed cell volume with increased calf gains to 4 weeks of age.

EFFECTS OF CERTAIN ANTIBIOTICS IN THE TREATMENT OF VIBRIOSIS. C. V. Hulet, S. K. Ercanbrack, D. A. Price, and R. D. Humphrey, *U. S. Sheep Experiment Station, USDA, Dubois, Idaho,* in Collaboration with F. W. Frank and W. A. Meinershagen, *Idaho Agricultural Experiment Station, Caldwell, Idaho.*

Outbreaks of vibriosis occurred in two bands of ewes at the U. S. Sheep Experiment Station which were being fed hay on the ground and watered from deep wells. To test the relative effectiveness of certain antibiotics as a treatment for this

abortion disease the young ewes (2, 3, and 4 years of age) were alloted at random within line of breeding and age group into control and various treatment groups. Approximately 80 mg. of chlortetracycline per head per day in grain pellets increased the percentage of ewes having at least one live lamb 8 to 10% above that of the untreated controls (differences significant only in one band). Two 4-cc. injections on consecutive days of penicillin-streptomycin increased the percentage of ewes having at least one live lamb 13 to 17% above the untreated controls. When the injected antibiotic was given in combination with 80 mg. of chlortetracycline per head per day in grain pellets, the percentage of ewes having at least one live normal lamb was increased 11 to 15% above the untreated controls. All treatments involving the injected antibiotic differed significantly from expectations based on the untreated controls. The differences among antibiotic treatments were not significant. It is not clear whether the effectiveness of the penicillin-streptomycin injections without chlortetracycline was conditioned by an immunity developed after infection, the prevention of subsequent infection by improved sanitation resulting from bunk feeding after treatment began, or other undetermined factors.

STILLBIRTH AND NEONATAL MORTALITY IN SWINE. R. E. Mauer and E. S. E. Hafez, *Washington State College, Pullman.*

Two hundred forty-seven piglings were farrowed; stillbirths and neonatal deaths (up to 10 days postnatal) were weighed and completely dissected. The percentage of stillbirth was 4.86 and the male:female ratio was 1:1. The percentage of neonatal deaths was 10.52 and the male:female ratio 1:1.60. The percentage of litters suffering losses from stillbirth and neonatal mortality were 29.62 and 51.85, respectively. The number of stillbirths or neonatal deaths ranged from 1 to 4 per litter. Litter size ranged from 4 to 14 and had no significant correlation with number of stillborn or neonatal dead. The average birth weight of stillborn was 18% lower than the average live birth weight. Birth weight was negatively correlated with number of stillborn ($r=-.7275$) and number of neonatal dead ($r=-.4338$). Stillbirth was related to mechanical obstruction at birth, congenital debility of the mother, managerial stress and hereditary factors.

EFFECT OF VARYING LEVELS OF HYDROXYZINE ON BLOOD CHARACTERISTICS AND FEED LOT PERFORMANCE OF STEERS. A. T. Ralston and I. A. Dyer, *State College of Washington, Pullman.*

Twenty-eight yearling Hereford steers averaging 780 lb. were fed five levels of hydroxyzine in an experiment of completely randomized design. Six steers per lot were fed 2.5, 12.5, 62.5 and 312.5 mg. of hydroxyzine per head per day, four steers serving as a control. Periodic weights and venous blood samples were taken during the feeding trial. Three animals per treatment were placed in metabolism stalls at the end of the feeding trial and total 24-hour excreta were collected. Daily gains were increased 0.25 lb. per day with the 2.5 and 12.5 mg. level of hydroxyzine. Feed efficiency for 12.5, 2.5 and 62.5 mg. level exceeded the control; however, it was not significant at $P=0.05$. Fecal excretion was significantly reduced at the 312.5 mg. level. At the end of 1 month blood epinephrine (B.E.) was significantly increased at the 312.5 mg. level. However, at the end of the trial 62.5 mg. level showed significantly less B.E. than 2.5, 12.5 mg. and controls; the 312.5 mg. level had significantly less B.E. than the 12.5 mg. and control. Shrink in transit and color of carcass lean were not affected by dietary treatments.

EFFECTS OF THE TRANQUILIZER TETRAHYDROZOLINE ON CATTLE. H. J. Weeth, L. H. Haverland and D. W. Cassard, *University of Nevada, Reno.*

In a Latin square experiment 12 weanling Hereford heifers were injected subcutaneously with 0.00, 0.02 and 0.04 mg. per lb. of body weight of tetrahydrozoline

hydrochloride. Immediately before injection, rectal temperature, pulse and respiration were taken and a sample of jugular blood was drawn. Three hours after injection, this procedure was repeated. One week was allowed between injections. Heifers injected with tetrahydrozoline had lower pulse rates and higher rectal temperatures. Tranquilized animals had somewhat slower respiration. However, the F value for differences between treatment groups was not significant, the probability being slightly greater than 10%. The tranquilizer caused a significant hyperglycemia, blood glucose being 78.34 ± 2.18, 193.99 ± 2.71 and 206.44 ± 4.71 mg. % for the 0.00, 0.02 and 0.04 mg. levels, respectively. Preinjection blood glucose was 73.81 ± 1.97 mg. %. Blood pyruvic acid was not affected by the treatments.

The stress of handling and bleeding caused a significant eosinopenia. Preinjection counts were 139 ± 15 *vs.* 92 ± 9 eosinophils per mm^3 for 3 hours postinjection. Tetrahydrozoline had no effect on the concentration of circulating eosinophils.

CLEAN YIELD OF PACKAGED GREASE WOOL FROM DIMENSIONAL MEASUREMENTS. Alexander Johnston, Svend-Aage Larsen and John T. Larsen, *University of Wyoming, Laramie.*

Two experiments were undertaken to measure the relationship between physical characters of packaged grease wools and the yield of clean fiber in the grease wool. On 100 miniature bags of grease wool the weight, length circumference, width circumference, staple length, density, fiber diameter and wool crimp were measured and compared to each individual bag yield. The seven variables accounted for 68% of the variation in yield, and the relationship (R) between the characters and yield was 0.821 which was highly significant. The error of estimate of yield on one lot of 10 miniature bags was $\pm 2.75\%$. This procedure was then applied to 25 commercial bags of graded grease wool of Fine, ½ blood and ⅜ blood qualities and each individual bag yield was measured. The three factors of bag weight, length circumference, and staple length compared to yield gave a high relationship (R) of 0.957 and accounted for 91.48% of the bag yield variations. The standard error of estimate for 5 bags was found to be 1.88 lb. of clean wool and for 10 bags 1.33 lb. of clean wool. In terms of shrinkage of the grease wool the accuracy of prediction on a group of 5 bags was $\pm 1.27\%$, and for a group of 10 bags it was $\pm 0.90\%$.

EFFECT OF ESTRADIOL AND TESTOSTERONE INJECTIONS AND THYROIDECTOMY ON WOOL GROWTH IN SHEARING SHEEP. S. B. Slen and R. Connell, *Canada Department of Agriculture, Lethbridge, Alberta.*

An experiment was conducted to determine the effect of relatively high doses of estradiol and testosterone, with and without thyroidectomy, on clean wool production and certain endocrine glands of shearling sheep. The administration of 5 mg. of estradiol intramuscularly at biweekly intervals to sheep with thyroids caused a significant reduction in the average weight of clean wool ($p<.01$) and fibre length ($p<.05$). This treatment produced significant increases ($p<.01$) in thyroid weight, pituitary and adrenal weights. When this hormone was administered to thyroidectomized ewes, the weight of clean wool was reduced significantly ($p<.05$) when compared with the thyroidectomized controls, but no response was observed in wethers. It would appear that the decrease in wool production due to estradiol treatment resulted from increased adrenal-pituitary activity. Testosterone administered at 175 mg. biweekly produced no effect on weights of clean wool, but when it was administered to thyroidectomized animals average fibre lengths were decreased significantly ($p<.05$).

FACTORS AFFECTING THE LEGIBILITY OF SHEEP BRANDING FLUIDS.

L. O. Wilson, D. A. Price, S. K. Ercanbrack and W. H. Kyle, *U. S. Sheep Experiment Station, Dubois, Idaho.*

Two scourable branding fluids developed by the USDA and six other fluids were tested for relative legibility and scourability on sheep at four locations in Idaho. A total of 3,760 observations were taken from 1954 through 1956. Sheep with fleeces that graded from fine to ¼ blood were branded immediately after shearing and legibility scores ranging from 1 (most legible) to 5 (least legible) were recorded 6 months later. Samples of wool containing the various kinds of branding fluids were subjected to commercial scouring, processing tests, and reflectance readings. Two fluids were found to be nonscourable, two moderately scourable and four scourable. A least squares method of analysis was used by which estimates of the independent effects of kind of fluid, color of fluid, length of staple, grade of wool and location were obtained. The average legibility score of the two USDA fluids was significantly ($P \leq .05$) better than that of two foreign scourable fluids but significantly poorer than that of two less scourable commercial fluids. The average legibility score of the four most scourable fluids was significantly poorer than that of the four least scourable fluids. Brands from USDA formula G were, in every trial, sufficiently legible for practical use. The average legibility score of red and black fluids was superior to that of all other colors in every trial, differences being significant in two of four trials. Increased staple length was accompanied by significantly decreased legibility in two of the three trials in which staple length was observed. The average legibility score of fleeces graded fine and ½ blood was significantly better than that of fleeces which graded ⅜ and ¼ blood, and brands on ⅜ blood fleeces were significantly better than brands on ¼ blood fleeces. There were also significant effects associated with locations.

NEWS AND NOTES

Meeting of the American Society of Animal Production. The 51st annual meeting of the American Society of Animal Production will be held at the Hotel Sherman in Chicago on November 27 and 28, 1959. Sectional meetings will be held Friday, 9:30–11:00 a.m. and 1:00–4:00 p.m.; and on Saturday 9:00 a.m.–4:00 p.m. and 7:30–9:30 in the evening. The General Session will be held Friday, 11:00 a.m.–12:00. Annual Dinner and Business Meeting will be held Friday evening, at 6:00 pm.

The United States will be represented at the International Dairy Congress in London, June 29 to July 3, by the presentation of approximately 30 technical papers from leaders in the field of dairy science. Dr. R. E. Hodgson, Director of the Animal Husbandry Research Division, ARS, USDA, is this country's liaison representative for the Congress. He will take part in a symposium concerning the economic outlook for dairying. Among others scheduled to participate in the Congress are: G. Malcolm Trout, Professor of Dairy Management, Michigan State University; S. T. Coulter, Professor of Dairy Husbandry, University of Minnesota; E. L. Jack, Head, Department of Dairy Industry, University of California, Davis.

A symposium on "Magnesium in Agriculture" is being arranged at West Virginia University, Morgantown, for September 3–4, 1959. The meetings will be held in the University Medical Center Auditorium. A tenative program of papers has been prepared covering such topics as, magnesium in soils and crops, its role in plants and animals (ruminants and non-ruminants), and its relation to "Grass Tetany." Further information can be obtained by writing G. C. Anderson, Head, Department of Animal Husbandry, West Virginia University, Morgantown.

Diet in Relation to Reproduction and the Viability of the Young. Part II. Sheep: World Survey of Reproduction and Review of Feeding Experiments by W. Tomson and F. C. Aitken; 93 pages; 30s; Commonwealth Agriculture Bureaux, Farnham Royal, Slough, Bucks, England, 1959.

This publication (Technical Communication No. 20) is divided into two parts, part I containing 59 pages with 245 references to data used in tabulation by countries of the reproductive performance of sheep of different breeds. Fourteen countries in Europe are covered in the survey, four in Africa, two in each of North and South America, three in Asia, and two in Australasia. Part II with 134 references briefly summarizes data on the effect of plane of nutrition and specific nutrients on fertility, reproduction and lactation; requirements or recommended nutrient allowances (mostly N.R.C., U.S.A.); and, substances (oestrogens and goitrogens) adversely affecting reproduction.

Elements of Dairying Laboratory Manual by E. E. Bartley, F. E. Eldridge, E. L. Farmer, F. C. Fountaine, and G. B. Marion; 120 pages; $3.75; Burgess Publishing Company, Minneapolis, Minnesota.

This is the second edition of a manual prepared for a college class meeting fifteen times a semester. The manual contains numerous exercises, problems, and demonstrations covering such a variety of topics as milk composition, quality of dairy products, the dairy processing plant, feeding and management of dairy cattle, artificial breeding and dairy cattle judging. The manual is well illustrated with photographs and drawings.

Symposium on Forage Evaluation. A combined reprint of the eight articles on Forage Evaluation given at the Intersociety Symposium at Purdue University, August, 1958, and appearing on pages 312 to 347 of the Agronomy Journal, Vol. 51, April, 1959, are available. These reprints may be ordered from the American Society of Agronomy, Central Office, 2702 Monroe Street, Madison 5, Wis. Price, 80 cents.

A. L. Musson, Head of the Animal Husbandry Department, South Dakota, has also been named an Assistant to the Dean and Director in charge of Farm Operations, effective July 1.

C. A. Lassiter has been appointed Head of Michigan State University's Dairy Husbandry Department. He succeeds N. P. Ralston who was named Director of Extension and Assistant Dean of the College of Agriculture.

Samuel H. Work, Agricultural Attache to Santiago will return to Washington for reassignment. He is to be succeeded by John S. Burgess.

Floyd Davis, former Chief, Livestock, Livestock Products and Poultry Branch, ICA, Washington, has been named Food and Agriculture Officer, USOM, Athens, Greece.

Leslie E. Johnson, Head, Department of Animal Husbandry, Iowa State University, is on a 3-month's assignment as beef cattle consultant to USOM, Israel.

John J. Mixner, Professor and Research Specialist in Animal Physiology, Rutgers University, received the 1959 New York Farmers Award at the Kinckerbocker Club, New York City, April 14.

William H. Gregory, Alabama Extension Livestock Specialist, resigned effective April 30, 1959. He served Alabama as specialist in the fields of beef cattle and sheep production and marketing since 1940.

James D. Blucker, Arkansas Extension Animal Husbandman, resigned April 15, 1959, to accept the position of executive Vice-President of the North Little Rock Stockyards.

Robert H. White, became Extension Specialist in Animal Husbandry in Kentucky, February 9, 1959. He is a native of North Carolina and received his B.S. and M.S. degrees at North Carolina State.

INFORMATION FOR CONTRIBUTORS

1. Papers may be submitted reporting work whose ultimate objective is clearly the solution of a livestock production problem and whose contents should be of interest particularly to those dealing with livestock production problems. Review papers on subjects of general interest will also be published at intervals, and will be prepared on invitation by the Editorial Board.

2. All papers will be subject to critical review by the Editorial Board, or others designated by the Editor. Papers needing revision will be returned to authors and should be revised and returned promptly. Papers not suitable for publication will be returned to authors with a statement of reasons for not accepting them.

3. Papers submitted should be based on new and adequate information. The following are guides to style and form:

   (a) Manuscripts must be typed, double-spaced and the ribbon copy submitted.

   (b) Pages must be numbered. The lines of text must be numbered in the left margin, beginning with one at the top of each page. This does not apply to tabular material.

   (c) Tables should be as few and as simple as is feasible for presentation of the essential data.

   (d) Legend for each figure should be typed on a separate sheet. Photographs should be carefully prepared and labeled. Magnification of photomicrographs should be indicated on legends. Charts should be prepare in India ink. Typed material on charts is not acceptable. Material that will not reproduce satisfactorily will be returned for revision. For suggestions on preparing illustrative material see the "Style Brief" published by the Wistar Institute Press, Philadelphia. If in doubt, consult the Editor before putting material in finished form.

   (e) The introduction should consist only of a paragraph indicating very briefly the nature of the question asked and the reason for asking it. Reference to relevant literature should be made later in the discussion of the results. Concise presentation of data is desired and there should be evidence of statistical examination wherever obviously useful in the interpretation. Unsupported hypotheses should be avoided. The organization of a manuscript may vary with the nature of the material, but all manuscripts should contain a clear statement of application of the results or their relation to some problem of the livestock industry. Each paper should end with a brief summary in the form of an abstract containing the most pertinent data in the briefest possible form.

   (f) Literature citations must be listed in alphabetical order and should be referred to in the text by author and date, i.e., Castle (1924), or (Castle, 1924). Citations may be referred to by number in review articles where the number of citations is too great to permit convenient use of the above form. "Literature cited" lists should be typed in a style used in a current issue of the JOURNAL.

4. Manuscripts will be edited in the order received, and accepted papers will be published as nearly in this order as feasible.

5. There will be a charge for making engravings in excess of one page per paper and of printing tables in excess of two pages per paper. The author will be asked when his manuscript is accepted to indicate the institution, agency or individual that will assume responsibility for the charges and for the reprints ordered at that time.

6. Authors will receive galley proof of articles together with a form for supplying an abstract for "Biological Abstracts." *Corrected proof and abstract should be mailed to the Editor within three days after they are received. Failure to do this may result in delay of publication until the next issue.*

7. One author of each manuscript should be a member of the Society. Papers by non-members can be published only after approval by the Executive Committee.

8. A "News and Notes" section will be published in each issue, including Society announcements, changes in positions and other items of professional interest to members. All such items should be sent promptly to the Editor.

9. Abstracts of papers to be presented at the annual meetings of the Society will be published in the November issue. Such abstracts must not exceed 250 words in length, should be typed (double spaced) and the ribbon copy submitted, the lines on the page should be numbered, in the left margin, from top to bottom, and must be in the hands of the Secretary of the Society by August 15, preceding the meeting. These abstracts must be summaries of results and conclusions.

10. Presentation of a paper at the annual meeting does not exclude it from publication in complete form in the JOURNAL. Such papers may be submitted to the Editor and will be given equal consideration with others submitted.

11. All manuscripts and correspondence concerning them should be addressed to the Editor: Dr. W. D. Gallup, Department of Biochemistry, Oklahoma State University, Stillwater, Oklahoma, or to the publisher: Boyd Printing Company, Inc., 49 Sheridan Ave., Albany 10, N. Y.

12. All correspondence concerning subscriptions to the JOURNAL OF ANIMAL SCIENCE and other business matters should be addressed to the Business Manager, Dr. H. H. Stonaker, Department of Animal Husbandry, Colorado State University, Fort Collins, Colo., or to the publishers, Boyd Printing Company, Inc., 49 Sheridan Ave., Albany 10, N. Y.